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RECENT IMPROVEMENTS ON THE OREGON SHORT LINE R. R.

By W. P. Hardesty, C. E.*

The great increase in weight of rolling stock and loads, length of trains, volume of traffic, and also the demands for higher speed during the past few years have impelled most of the railways that could afford the expenditure to build stronger bridges and to rectify grades and curves.

The Oregon Short Line R. R. Co., operating 1,232 miles of track in Utah, Wyoming, Idaho and Montana (all lying north of Salt Lake City), has rebuilt many bridges and greatly improved its roadbed during the past few years. Up to the present time, the most important changes have been in the bridges. The road had originally (including the entire Utah division) about 1,000 bridges. Many of these have been replaced by iron pipes, and some by concrete arch culverts. Nearly all pile trestles and Howe truss bridges on the main line, of any considerable size, have been replaced by steel structures.

In 1894-95, at a number of the more important river crossings in Idaho, steel trusses of the Pegram type† were substituted. This patented type of truss is the invention of Mr. Geo. H. Pegram, M. Am. Soc. C. E., who was then chief engineer of the Union Pacific R. R. Co., which operated the Short Line. The Pegram truss is intermediate in type between the Pratt and Warren trusses. In form it much resembles the bowstring truss. Its chief merits are the small amount of field riveting required, and the saving of material in the diagonal members. The effective depth of the top chords varies in proportion to the bending moments. The struts, or posts, are much shorter towards the ends than in the Pratt truss. The disadvantage is in more, and more difficult, shop-work as compared with the Pratt. The Pegram through truss is very high in the middle, but only of the usual height at the ends.

One of the Pegram bridges which was erected was at the crossing of Snake River, at American Falls, 26 miles west of Pocatello. This consisted of three 40-ft. and one 20-ft. girder spans, three 166-ft. Pegram trusses, and one 247-ft. Whipple truss, making a deck structure 892 ft. long over all. The Snake River here runs in a small canon, with solid rock for the bed of the river. Directly under and near the bridge there are some shallow falls, amounting altogether to about 40 ft. Near the west side there is a small island of solid rock. On this island is built the power house of the American Falls Light & Power Co., which utilizes the fall of the river here in the production of power. Current for lighting is transmitted to Pocatello and to Blackfoot. Two other water-power companies, one on either side of the river, are also building plants at this place.

As the increasing train loads were becoming too heavy for the 247-ft. Whipple truss, it has lately been rebuilt. As piles could not be driven at this place, owing to the solid rock bottom, a temporary Howe truss bridge was erected for the falsework of the new steel span. This falsework structure reached from the island to the shore, a distance of about 175 ft. The steel span reaches from the island to the west cliff. The material for this span was furnished by the Lassig plant of the American Bridge Co., while the erection was by the railroad company's own force. Fig. 1 shows the bridge with the Howe truss in position under the 247-ft. span.

About 2½ miles east of Huntington, Ore., which is the western terminus of the road, is the last crossing of the Snake River, which here runs in a canon. The bridge (No. 379) consisted of two 182-ft., one 176-ft., and one 188-ft. spans, all of Pratt deck trusses. These were rebuilt in 1902, owing to the old spans being too light. (See Fig. 2.)

Between Granger, Wyo., and Pocatello, Idaho, no less than six lattice truss bridges, varying

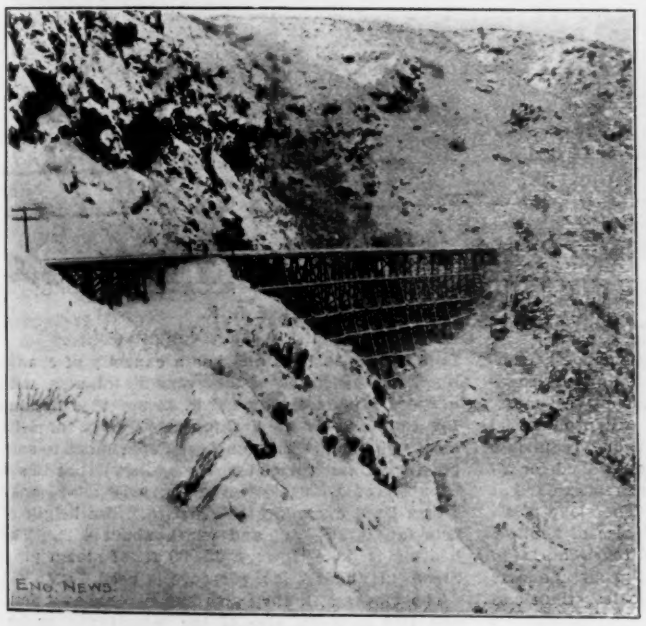

FIG. 3. THE OLD TIMBER TRESTLE.

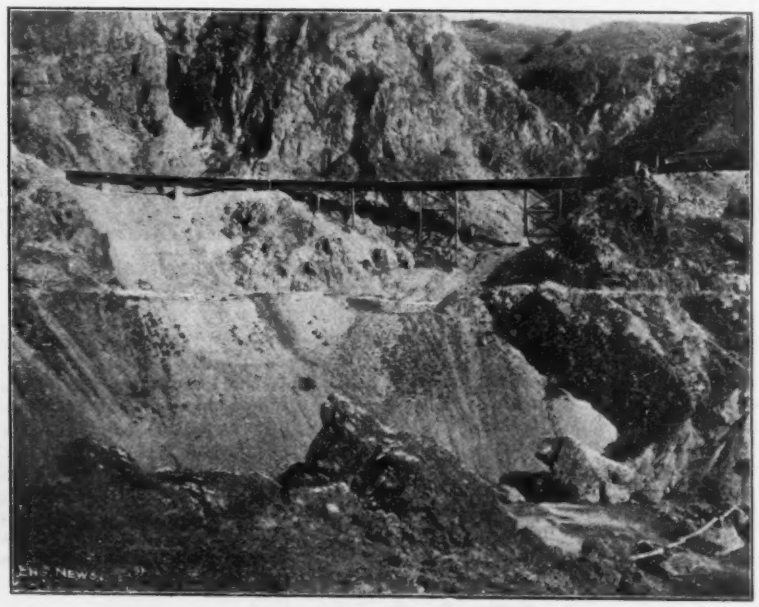

FIG. 4. THE NEW STEEL VIADUCT.

BRIDGE NO. 532 ON THE OREGON SHORT LINE R. R. IN BEAR RIVER CANYON, UTAH; OLD AND NEW STRUCTURES.

*Montpelier, Idaho.

†See Eng. News, Vol. Jan.-June, 1891, p. 134, for full description of Pegram truss.

from 110 to 140-ft. span, were erected in 1900 and 1901, replacing pile trestles. All erection or field work since August, 1900, has been by the company's own force.

In the Bear River canon in Utah is encountered some of the most difficult country along the entire line. The line follows along the rocky slopes on the east side of the canon, consisting mostly of cliffs broken at intervals by short side gulches. In two of these places, where no supporting ground can be found for a roadbed, trestles are necessary. Timber trestles have served, since the standard-gaging of the road in 1889, till recently, when steel ones were substituted. Bridge No. 532, which replaces a timber trestle of five stories, is 504 ft. long. There are 10 spans, three of which rest on short piers and abutments and seven on steel towers. Each tower covers 31½ ft. of line and rests on four concrete pedestals. The spans between towers are 63 ft. long, while the tower spans are but 31½ ft. The bridge is 80 ft. high from the top of masonry at the highest tower to base of rail. The largest pier is 40 ft. from top to bottom of footing, and it contains 110 cu. yds. All the piers and abutments, including coping, are of the best concrete work. The superstructure is a steel plate girder, 6 ft. deep, made of medium open-hearth steel. The bridge is on a 10° curve, and the ties are tapered to give the curve elevation. Three iron guard rails are provided between running rails.

Bridge No. 533, near by, has a length of 315 ft. and a height of 65 ft. at the highest tower. It is of the same type as the preceding. These bridges are located a very short distance below the dam across the river for diverting water into the Bear River canals (Eng. News, Feb. 6, 1896).

The standards of the Union Pacific R. R. for bridge construction are used on the Short Line. The specifications are practically the same as Cooper's E 50. The live load is figured for two engines, each (including tender) weighing 345,000 lbs., followed by a uniform load of 4,000 lbs. per lin. ft. All substructures are now built of concrete. Beam girders are preferred up to 20 ft length, and riveted girders from that up to 95 ft., with riveted lattice trusses up to 150 ft.

FIG. 1. BRIDGE OVER SNAKE RIVER, AMERICAN FALLS, IDAHO, OREGON SHORT LINE R. R.

ROADBED, GRADES AND CURVES.

The Idaho Division, reaching from Granger, Wyo., to Huntington, Ore., was located and built about 1882, under supervision of Jacob Blickensderfer, then chief engineer of the Union Pacific R. R. The location is a very good one, considering the standards then prevailing on western roads. With the exception of one 5° curve at Diamondville, Wyo., there are no curves sharper than 4° on this division, except two or three of 6° in the Snake River canyon, very near the west end. Going westward from Granger, the ascent to Ham's Fork tunnel (on mile 43) is accomplished with a maximum grade of 0.76% (40 ft. per mile), reaching for but a short distance. The descent of the west slope requires a maximum of 1.5%.

The Ham's Fork tunnel is the only tunnel on the entire Short Line system, except a very short one in the Bear River canon. It was originally timbered, but has since been lined with concrete, with a brick arch. Its length is 1,426 ft., and its summit elevation is 7,083 ft., which is the highest point reached by the Short Line.

An interesting experiment has been tried at this tunnel, which has resulted successfully. To keep the approach cuts clear of snow, a total length of about 1,100 ft. of snowsheds have been in use; but much snow drifted through, and ice also formed under the sheds, and remained unmelted till far into the summer. Recently the sheds have been removed, and the cuts widened to 28 ft. At a height of about 20 ft. above the bottom, a 12-ft. berme was excavated on each side, above which the slope (1¼ horiz. to 1 vert.) continued to the surface. The bermes were made to catch the snow coming from a rotary plow, as the cut is too deep to throw it entirely out, and the cut was made the extra width to allow of more sunlight and to provide room at the sides for part of the snow. This arrangement works much better than the snowsheds. The lining of the tunnel and the reduction of the grades on the east slope to the present limits were done in 1899-1901.

So far the line changes have been mostly confined to the right-of-way. In widening the roadbed and rectifying the grades and curves, many minor changes have been made. All pronounced sags in the track have been taken out, requiring, in some cases, a raise of 6 ft. The roadbed for all the main line has been widened to the standard of 24 ft. for cuts and 18 ft. for fills. The slope of all cuts in earth and loose rock, and also of shallow solid rock cuts, has been flattened to 1½ horiz. to 1 vert. Most of the rectification of grade, made at the time of widening, amounted to less than one foot.

Heavier rails have been substituted for the older ones as fast as practicable, and the ones released are used on branches and for sidings; 80 lbs. is the standard weight at present for all new rails.

The portion of the line from Nampa to Olds Ferry, Ida. (73 miles) is very dusty, and oil is being used to lay the dust. The oil is a heavy residuum from the oil wells of California.

The Utah & Northern R. R., now a part of the Oregon Short Line, was begun in the late 70's. It reached from Ogden to Silver Bow, Mont., and was narrow-gage. It was standard-gaged in the late 80's. The track from Pocatello to Silver Bow (255.5 miles) was widened in one day, on July 25, 1887.

NEW SHOPS AT POCATELLO.

Pocatello is the natural center of the Short Line system, where the main north and south line crosses the main east and west one. It has always been the principal division point, and to provide facilities for the increasing work the railroad company has lately built one of the best arranged shop plants in the west.

The main building is 486 × 150 ft. outside dimensions, 44 ft. in height to the eaves and 63½ ft. to top of the lantern. It is of the usual "shop" construction, of brick and glass, with pitch and gravel roof. At the southerly end is the boiler and tank shop. Next is the machine and erecting department, 221½ × 146½ ft. Next to this is the blacksmith shop, and at the north end is the wheel and truck shop.

Extending the full length of the east side of the machine department is a gallery, 36½ ft. wide. At the north end of this gallery is the general foreman's office. The entire west half of the machine room is set aside for handling and repair of locomotives. There are 10 engine pits, each 45 ft. long. Overhead is a traveling crane with 69¾ ft. span. This crane has a capacity of 100 tons, and it was tested to 125 tons. It is provided with two 50-ton hoists and an auxiliary hoist of 10 tons.

The main building and also the roundhouse are heated by means of exhaust steam from the power house. The indirect system is used, the steam passing through coils which heat the air that is forced by Sturtevant fans where needed. There is one fan for the boiler and tank shop and one for the blacksmith and wheel shops. Each of these

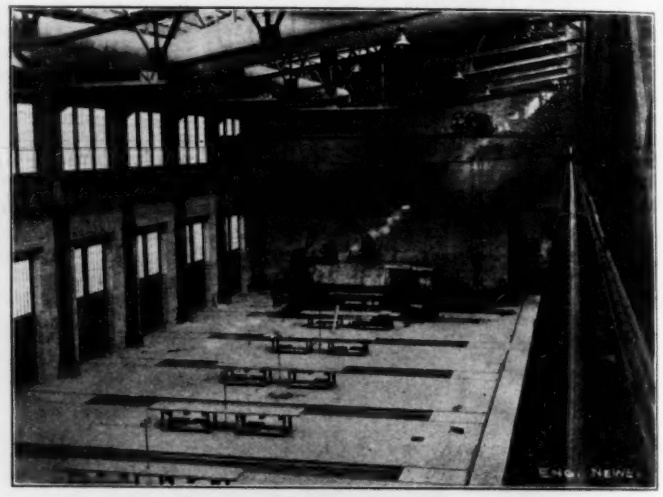

FIG. 6. ERECTING DEPARTMENT, NEW POCATELLO SHOPS; OREGON SHORT LINE R. R.

fans is 13⅓ ft. high and has a capacity of changing 1,100,000 cu. ft. of air every 20 minutes, with a speed not exceeding 207 r. p. m. The heating for each fan is done through 8,000 ft. of 1-in steam pipe coil. The machine department is supplied by a fan (placed in the gallery) that has a capacity of 1,750,000 cu. ft. every 20 mins., with a speed not exceeding 165 r. p. m. The height of this fan is 16⅔ ft., and width about 4 ft. The heating is done through 15,000 ft. of steam pipe. Steam at about 2 lbs. pressure is used.

The blacksmith shop also has two exhaust fans and two blowers, also of the Sturtevant make. Tile pipes laid under the floor serve as conveyors for the air.

For the full length of the row of columns in the center of the building, a branch pipe for air and one for live steam, also a plug for electric light connection, are provided at every second column.

To the east of the shops is a 30-stall roundhouse. This is also heated by hot air from the main plant. At every alternate space between engine pits is an outlet from which, by branch pipes, hot air is discharged at the front and rear ends of each engine pit. This is very useful in warming up the engines before firing up. The turntable is run by an electric motor of 7½ HP.

Alongside the main building on the west is the transfer table. This is 80 × 522 ft., and will carry a load of 200 tons on the 6 rails. The table is operated by a 50-HP. motor. The site was filled in with gravel, to bring it up to the level of the main floor. As part of the plan of a complete shop

plant, there are yet to be built a car shop, a storehouse and a foundry. The car shop will be about the size of the main building, and will be west of the transfer table.

The shops have a sewerage system of their own. A line of 18-in. vitrified clay pipe, 7,600 ft. long

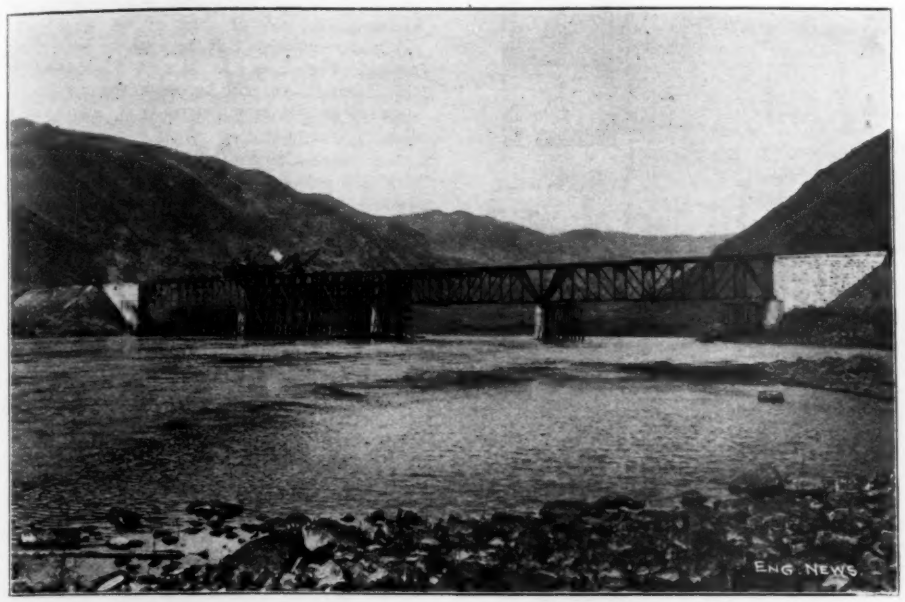

FIG. 2. RENEWING BRIDGE OVER SNAKE RIVER, NEAR HUNTINGTON, OREGON; OREGON SHORT LINE R. R.

and laid to a grade of 0.15%, discharges through 1,000 ft. of open ditch into a branch of the Portneuf river.

Shortly below the main building is a series of 8 catchbasins, designed for the arrest and removal of the more solid parts of the sewage. The worst of these are the boiler scales, etc., resulting from the cleaning out of the engines at the roundhouse. These very soon deposit and solidify on the bottom of the sewer unless removed. At each catchbasin, which is a long oval in plan, a hood is placed over the outlet, which causes the sewage to pass under its lower edge (about 3 ft. lower than the outlet). The more solid parts do not readily rise under the hood, but sink to the bottom. Every few days the deposit is removed by hand.

For the data from which this article has been prepared, the writer is indebted to Mr. Wm. Ashton, Resident Engineer of the Short Line system, and to Mr. John P. Congdon, Division Engineer at Pocatello. The latter was also engineer in charge of the steel trestles in the Bear River canon at the time of their erection, and has had charge of the construction of the new shops at Pocatello.

THE PENNSYLVANIA RAILROAD TUNNEL UNDER THE NORTH RIVER, AT NEW YORK CITY.

The proposition of the Pennsylvania R. R. to tunnel under Manhattan Island and the two great waterways which bound it on the east and west is one of the boldest in the history of engineering In a word, it is proposed to build at a cost of $50,000,000 a tunnel some 5¾ miles long partly on land and partly under water, and through one of the most unstable materials ever encountered by engineers in subaqueous tunneling. The preparations for so costly and difficult an undertaking have naturally been very complete, and the engineers' plans and specifications which have just been made public contain far more matter of interest than is usually the case in tunnel work where methods of construction are of far more importance than questions of structural design. For this reason we give these plans in considerable detail in this and a succeeding issue of Engineering News. In this issue attention is confined to the plans for the North River Division of the work. The East River Division of the work will be described in similar detail in a future issue.

HISTORY OF THE FRANCHISE.

The first definite announcement of the plan of the Pennsylvania R. R. to tunnel under the Hudson and East Rivers was its application early in December, 1901, for a franchise in perpetuity for the work. The charter of New York city prohibited the granting of perpetual franchises, and in order to grant the company's request it would be necessary to amend that charter. The great importance of the proposed work and the vast benefits which would result to the city from its execution made it seem desirable to grant this concession, and, accordingly, a bill was introduced into the New York State Legislature, which gave authority to the Municipal Assembly of New York city to grant perpetual franchises to tunnel under the city with certain restrictions to railways originating outside of the city. This bill was passed by the State Legislature and was forwarded to the Mayor of New York for approval.

Meanwhile the Board of Rapid Transit Railroad Commissioners had become concerned in the question. In order to carry out the work of a uniform and comprehensive system of rapid transit railways in New York city, for which it was constituted, the Board considered that all plans for underground and elevated railway construction in the city should go through its hands and be approved by it before a franchise was granted for the work. It was not clear that the Board already had this power, and in order to make this certain an amendment to the Rapid Transit Law was requested. The bill before the Mayor was approved by him, but in connection with it he urged the passage of the proposed amendment to the Rapid Transit Law. This amendment was, therefore, passed by the Legislature and in due course became law.

On May 5, 1902, the Pennsylvania R. R. interests made application to the Rapid Transit Commission in the name of the Pennsylvania, New York & Long Island R. R. Co. for a franchise for its proposed tunnel line. Certificate of approval was granted by the Commission on June 16, 1902, and was transmitted to the Board of Aldermen. This body refused to approve the certificate, and after much consultation and considerable acrimonious discussion between the parties concerned a new certificate of approval was prepared by the Board of Rapid Transit Railroad Commissioners, which was approved by the Board of Aldermen on Dec. 16, and by Mayor Seth Low on Dec. 23, 1902. The Pensylvania R. R. was now in position to go ahead with the actual prosecution of its undertaking. As a matter of fact, it had been at work on its plans long before this time.

ENGINEERING ORGANIZATION.

To carry on its proposed work the Pennsylvania R. R. created a special engineering organization. There were four classes of work to be considered and provided for, which could be defined as follows: (1) The tunnel construction proper; (2) the architectural work in connection with the terminals; (3) the mechanical and electrical engineering, and (4) the bringing of the railway into and through the tunnels and terminals. It was decided first that the whole work should be under the general direction and management of the Pennsylvania R. R. A Board of Consulting Engineers was then appointed and the various parts of the work were assigned to individual members of the Board as follows: Lieut. Col. Charles W. Raymond, Engineer Corps, U. S. A., Chairman of the Board; Charles M. Jacobs, M. Inst. C. E., Chief Engineer North River Division; Alfred Noble, M. Am. Soc. C. E., Chief Engineer East River Division; Wm. H. Brown, Chief Engineer Pennsylvania R. R., in charge of tracks and terminal yards; Gustav Lindenthal, Commissioner of Bridges, New York city, and George Gibbs, M. Am. Soc. C. E., in charge of mechanical engineering, electric locomotives and traction, and representing the firm of Westinghouse, Church, Kerr & Co., which has been placed in charge of the mechanical and electrical engineering work. The architects are McKim, Mead & White, of New York city, and Mr. Mead of this firm attends all the meetings of the Board and takes part in the deliberations .

FIG. 5. APPROACH TO HAM'S FORK TUNNEL; OREGON SHORT LINE R. R.

GENERAL PLAN.

The general plan of the Pennsylvania R. R. tunnel line comprises a tunnel from the west side of

the New Jersey bluffs opposite Manhattan under the North River, Manhattan Island and the East River to Long Island. In this article only that portion of the line comprised in the North River Division will be considered. This comprises part of the land tunnel under Manhattan Island, all

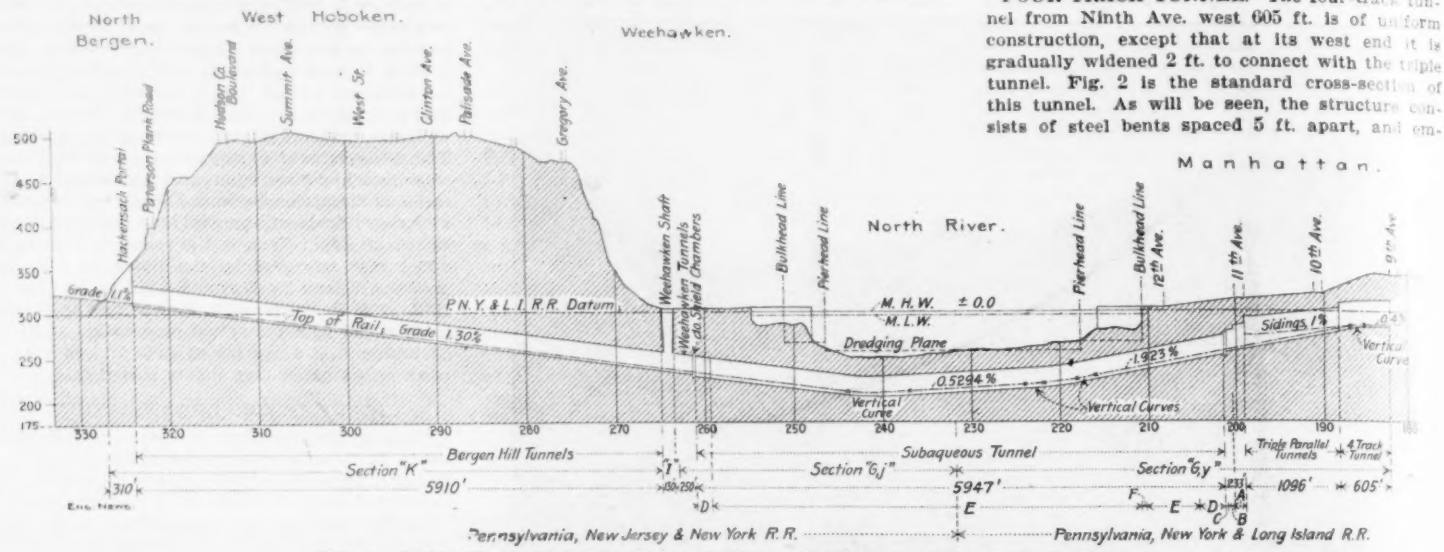

FIG. 1. PROFILE OF NORTH RIVER DIVISION OF PENNSYLVANIA R. R. TUNNEL.

of the North River tunnel and all of the land tunnel on the New Jersey shore. A profile of this portion of the line is given by Fig. 1.

Briefly described, the tunnel begins at the west line of Ninth Ave., in Manhattan, and extends to a point on the west side of Hoboken heights, at North Bergen. Its total length between these two points is 14,481 ft., or 2.74 miles. The tunnel structure varies in character several times in its length. From Ninth Ave. west 605 ft. it is four-track clear section tunnel. The next 1,096 ft. are triple parallel tunnels, composed of a generally rectangular section divided by two longitudinal partitions. The middle gallery of this triple tunnel merges into a clear section two-track tunnel 130 ft. long, and this two-track tunnel diverges into twin tube tunnels, which extend across the river, and of which 5,947 ft. are subaqueous tunnel. Two types of tube construction are employed, as will be described later. From the end of the twin-tube tunnel on the Jersey shore to the North Bergen portal there are 5,910 ft. of full center-arch, twin, single-track tunnels. There is also on the Jersey side a shaft 130 ft. long and a shield chamber 26 ft. long, and on the Manhattan side there is a shield chamber 27.5 ft. long, 75.5 ft. of 20-ft. span twin tunnels and a side shaft at Eleventh Ave. These various parts of the work all differ more or less, and will be described separately.

MANHATTAN LAND SECTION.

FOUR-TRACK TUNNEL.—The four-track tunnel from Ninth Ave. west 605 ft. is of uniform construction, except that at its west end it is gradually widened 2 ft. to connect with the triple tunnel. Fig. 2 is the standard cross-section of this tunnel. As will be seen, the structure consists of steel bents spaced 5 ft. apart, and embedded in concrete side walls and roof arch. Each bent is composed of two wall columns and a bow string roof truss. Only the top chord of the roof truss is embedded in the concrete roof arch. The successive bents are tied together longitudinally

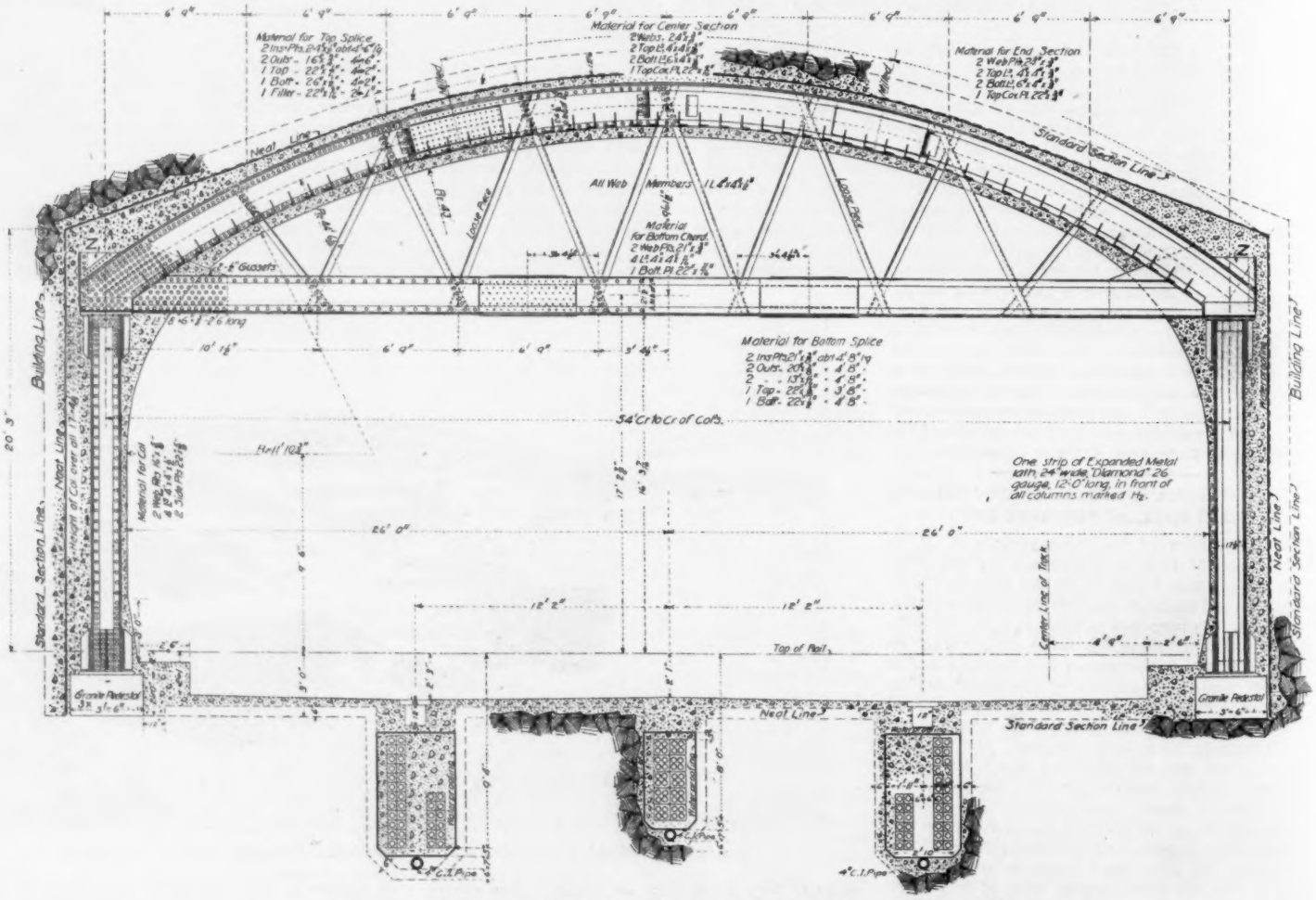
Material for Top Splice
Material for Center Section
Material for End Section
Neat Line
Standard Section Line
All Web Members
Material for Bottom Chord
Material for Bottom Splice
54' Cr to Cr of Cols.
One strip of Expanded Metal lath, 24" wide, "Diamond" 26 gauge, 12'-0" long, in front of all columns marked H.
Center Line of Track
Top of Rail
Granite Pedestal
Building Line
4" C.I. Pipe

FIG. 2. TRANSVERSE SECTION OF FOUR-TRACK TUNNEL IN MANHATTAN.

of the tunnel by channel braces at the haunches and at the crown, as indicated at M. At their ends the trusses are also connected by the pocket brackets Z, details of which are shown by Fig. 3. These brackets provide a pocket into which the

ends of the concrete roof arch set, and they convert the thrust of the arch into a vertical reaction on the columns and side walls. Another feature of the construction is the circumferential row of angles spanning the space between bents in the plane of the lower flanges of the top chord. These angles simply rest on the chord flanges and are held the proper distance, 12 ins., apart by means of the hoop iron clamps shown by Fig. 4. The composition of the various members of the bents, the limits of the concrete lining, the location of the cable conduits and the other principal features of the construction are shown by Fig. 2.

TRIPLE PARALLEL TUNNEL.—The four-track clear section just described merges into a triple parallel tunnel, which carries the line 1,096 ft. farther westward. This tunnel also provides for four tracks, two in the middle gallery and one in each side gallery. The double tracks in the middle gallery are on a descending grade westward, since they are the main line tracks which pass under the North River, but the side tracks are simply stub tracks, which terminate at the west end of the section, and which have an approximately level grade. Consequently the floor of the middle gallery, which is only about 2 ft. below the floors of the side galleries at the east end, is over 10 ft. lower than the side gallery floors at the west end. It will be understood from this that the cross-sectional profile of the triple tunnel varies at every point throughout its length. Only one cross-section is illustrated here.

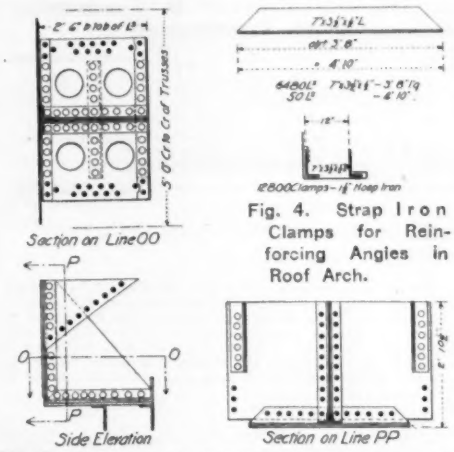

Fig. 4. Strap Iron Clamps for Reinforcing Angles in Roof Arch.

Fig. 3. Details of Pocket Bracket Z Between Roof Trusses.

This is taken near the west end and is shown by Fig. 5.

As will be seen, the tunnel structure consists of parallel transverse bents, each of which consists of two outside wall columns and two intermediate columns, the tops of which are connected by roof girders encased in reinforced concrete. These bents are tied together only by channel struts. The outside wall columns are embedded in the concrete side walls, and concrete partitions embed the intermediate columns. The roof consists of concrete filled up close against the excavation roof and carried in a platform of I-beams placed close together and spanning the space between bents. The roof girders and all parts of the steel structure not embedded in the walls, partitions and roof as described, are encased in metal lath and cement mortar. A waterproofing layer extends around the tunnel on the sides and roof. The other details of the structure, its main dimensions and the composition of the steelwork are clearly shown by the drawings of Fig. 5.

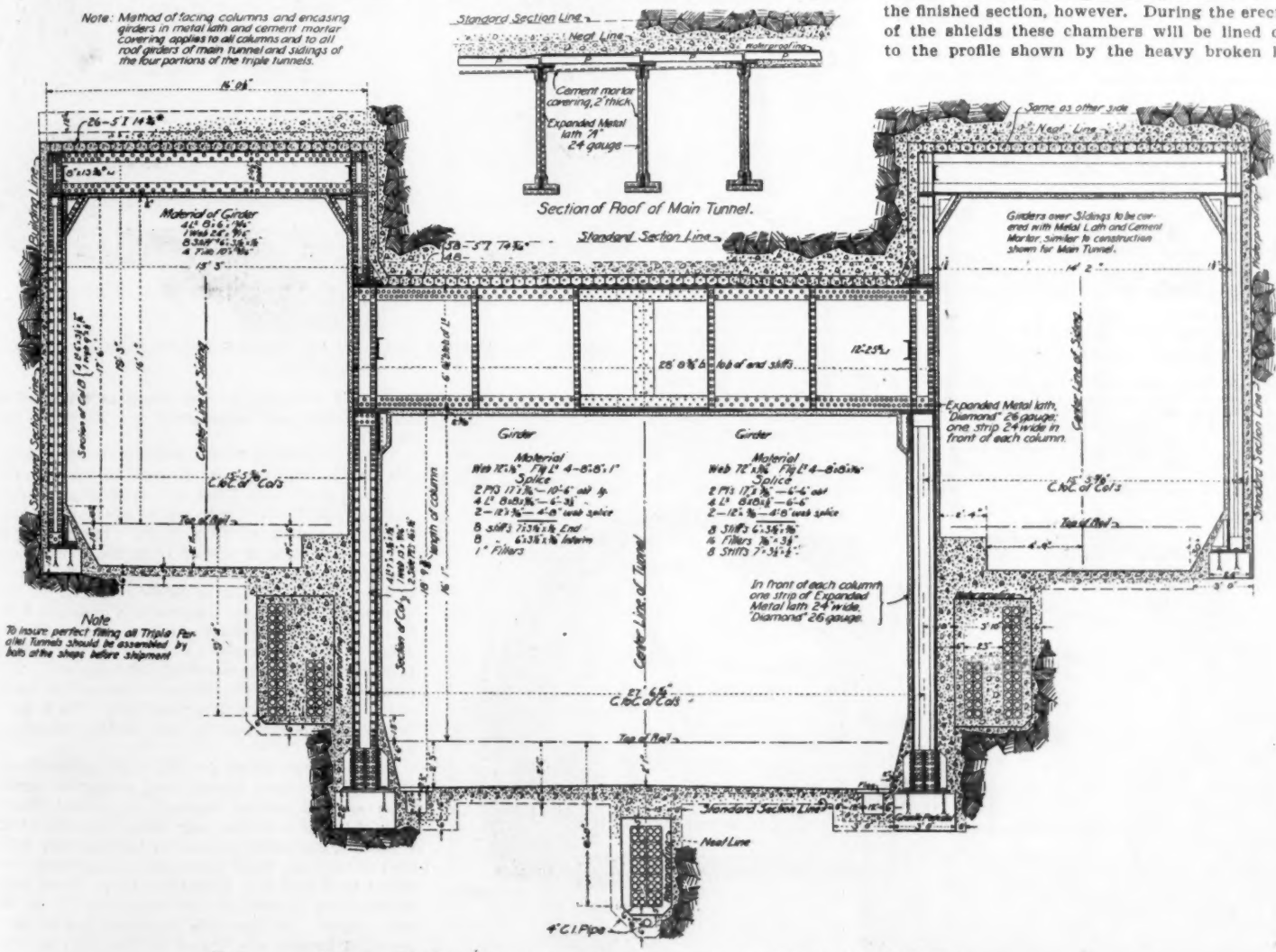
Note: Method of facing columns and encasing girders in metal lath and cement mortar covering applies to all columns and to all roof girders of main tunnel and sidings of the four portions of the triple tunnels.
Standard Section Line
Neat Line
Waterproofing
Cement mortar covering, 2" thick.
Expanded Metal lath, "Diamond" 24 gauge
Section of Roof of Main Tunnel.
Same as other side
Material of Girder
Girders over Sidings to be covered with Metal Lath and Cement Mortar, similar to construction shown for Main Tunnel.
Center Line of Siding
Girder
Material
Splice
Expanded Metal lath, "Diamond" 26 gauge, one strip 24" wide in front of each column.
In front of each column one strip of Expanded Metal lath 24" wide, "Diamond" 26 gauge.
Center Line of Tunnel
Note
To insure perfect fitting all Triple Parallel Tunnels should be assembled by both of the shops before shipment
4" C.I. Pipe

FIG. 5. TRANSVERSE SECTION OF TRIPLE TUNNEL IN MANHATTAN.

The shield chamber marks the limit of the Manhattan land section of the North River Division.

CONSTRUCTION.—The construction of the tunnel structure which has been described is required to conform to certain general restrictions laid down by the Board of Engineers, but the contractor has been left great freedom in selecting methods of work so long as he conforms to

twin-tube tunnel under the North River there are three transition structures. These are shown in plan by Fig. 6. The first of these structures is a concrete and brick arch structure of 34-ft. clear span, and its construction is shown in cross-section by Fig. 7. This structure calls for but little description. It is only 130 ft. long, and is a three-center arch with vertical sidewalls. The sidewalls and the skewback sections of the arch are of concrete and the roof is brick arch masonry The sidewalls each contain 12 high tension ducts and 24 low tension ducts, and in the floor at the center is an 80-duct telegraph and telephone conduit, and an 18-in. cast-iron drain pipe. The tunnel is waterproofed on the roof and sides.

TWIN-ARCH TUNNEL.—As shown by Fig. 6, the two-track arch tunnel merges into twin single track arches, at the west end of which is an enlargement which is to serve as a chamber in which to erect the shields for driving the twin-tube tunnels under the river. Fig. 8 is a plan and part section of the west end of the twin arches and the adjoining shield chambers, and Fig. 9 shows transverse sections of the same structures. Reference to the half-section DD shows the construction of each of the twin arches to be substantially the same as the construction of the two-track arch shown in Fig. 7. The shield chamber has a cast-iron curbing backed and lined with concrete. The half-section AA shows the internal dimensions of the shield chambers to be the same as those of the adjoining masonry arches. This is the finished section, however. During the erection of the shields these chambers will be lined only to the profile shown by the heavy broken line.

these general restrictions. They alone can be described at the present time. Practically all of the tunnel so far described must be driven with-

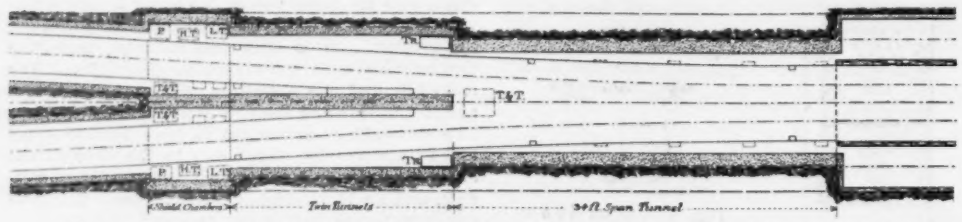

FIG. 6 PLAN OF JUNCTION OF TRIPLE TUNNEL, DOUBLE-TRACK TUNNEL AND TWIN-TUBE TUNNEL IN MANHATTAN.

out interfering with the street surface, and the following requirements will control the work.

Where tunnels are built of concrete or steel and concrete, the concrete is to be packed tight against the rock surface, but when brick masonry lining is employed a rock packing at least 4 ins. thick must be inserted between the brick and the rock surface to ensure perfect drainage. The neat lines on the drawings show the minimum thickness of lining and packing which will be allowed. This neat line may be changed by the engineer wherever it seems desirable. Excavation outside the neat lines is to be avoided so far as is practicable, but where timbering is required the excavation must be of sufficient dimensions to allow the timbering to clear the masonry lining and all voids between the excavation or the timbering and the masonry must be packed. No allowance will be made the contractor for excavation outside of the standard section line shown by the drawings, except, of course, when the engineer changes this line during construction. The standard section line is located 1 ft. outside the neat line for the roof and sides, and 6 ins. outside the neat line for the floor. Timbering must be employed wherever necessary to the prosecution of the work with safety. The centering for arched roofs must be of steel construction. Electric lighting of the workings and plant is required. All spoil is to be disposed of clear of the tunnel shafts and of the company's property.

The waterproofing of the tunnel is to be of the following character and construction:

In tunnels driven with shields, the cast-iron shells will serve as waterproofing. In tunnels driven in the ordinary manner without shields, the space between the sides of the excavation and the neat line shall be filled with concrete behind suitable forms. After the forms are removed the surface of the concrete shall be given a ½-in. coat of mortar containing equal parts, by volume, of Portland cement and sand and troweled smooth. After the mortar has set and dried out, it shall be covered with alternate layers of coal-tar pitch and felt, seven layers of pitch and six of felt. The felt shall be "hydrex" felt manufactured by F. W. Bird & Son, of East Walpole, Mass., or felt equally satisfactory to the engineer. The pitch shall be straight run coal-tar pitch which will soften at 60° F., and melt at 100° F., being a grade in which distillate oils, distilled therefrom, shall have a specific gravity of 1.105. The pitch shall be mopped on the surface of the concrete to a uniform thickness of not less than 1-16-in. Immediately on this coat of pitch and while it is still melted, there shall be laid a covering of felt previously mopped with pitch on the surface to be applied, the sheets to lap not less than 4 ins. on cross joints nor less than 12 ins. on longitudinal joints, and to be made to adhere firmly to the pitch-covered surface of the concrete everywhere. This felt layer shall be mopped with pitch as above specified, another layer of felt mopped with pitch and then added and the process continued to the full number of layers required. This waterproofing shall extend from the level of the bottom of the electric ducts to 15 degrees above the spring line of the roof arch. After the waterproofing has been placed the remainder of the concrete with the electric ducts, etc., shall be placed.

Where roofs of tunnels driven in the ordinary manner without shields are of brick, they shall be plastered with a mastic containing coal tar and Portland cement in such proportions as the engineer may from time to time require. This shall be applied with a trowel in a uniform layer ½-in. in thickness. This waterproof coating shall then be covered with one course of brick laid on flat in a bed of mortar ½-in. thick, containing equal parts by volume of Portland cement and sand, and the joints completely filled with mortar of the same composition. The junction between the waterproofing in the roofs and sides shall be formed so as to make a continuous waterproofing surface. Where the roofs of tunnels are of concrete built solidly against the rock, the waterproofing of the roof shall consist of grout injected through pipes built into the concrete at such intervals as the engineer may require.

Where tunnels are built by the cut-and-cover method, the sides, if in rock excavation, shall be waterproofed as described; if in earth excavation, they shall be waterproofed as herein specified for roof. The roofs of tunnels shall be plastered smooth and covered with coal tar and felt as specified for sides of tunnels. The waterproofing shall be covered with a 1-in. layer of mortar, containing equal parts, by volume, of Portland cement and sand. The mortar shall be laid on in areas about 5 ft. square, and when one square is set the adjacent ones shall be laid tight to it, this laying out in squares being for the purpose of relieving expansion or contraction. A thorough connection shall be made between the waterproofing of the top and sides.

The waterproofing of retaining walls and portals shall extend from the base of the wall to within 1 ft. of the top. Where the walls are built against the face of the rock excavation, the waterproofing shall conform to the requirements for sides of tunnels; where the wall is not built against a rock face, the waterproofing shall be the same as specified for tunnel roofs. No waterproofing will be used in the floors except where specially required by the engineer.

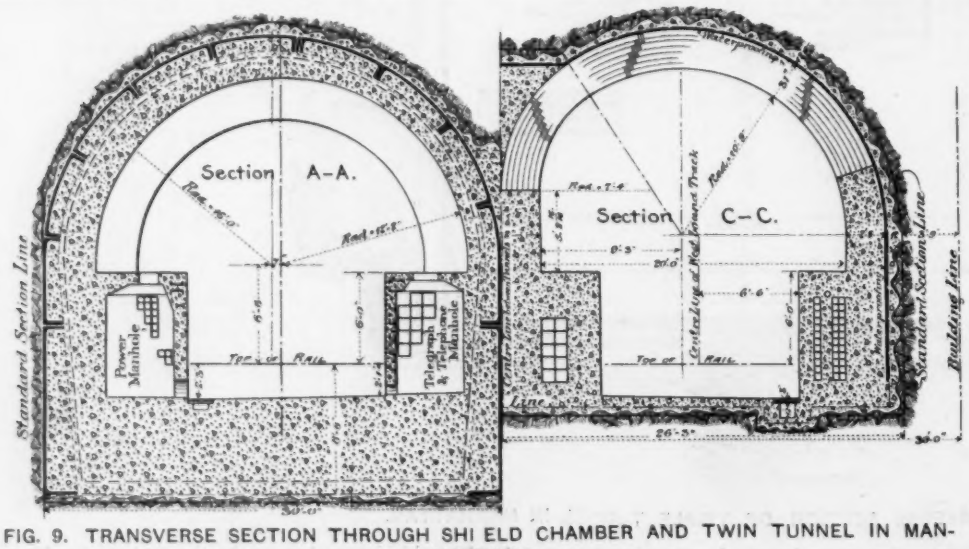

FIG. 9. TRANSVERSE SECTION THROUGH SHIELD CHAMBER AND TWIN TUNNEL IN MANHATTAN.

NORTH RIVER TUNNEL SECTION.

The North River tunnel is considered here to comprise all the tunnel coming between the shield chambers on the Manhattan shore and those on the Jersey shore. It is all twin-tube tunnel, and is all subaqueous work. Two styles of structure are employed, one with screw pile foundations and one without special foundation.

TUBE TUNNEL WITHOUT FOUNDATIONS.—The amount of tube tunnel without foundation is comparatively small. It comprises a section 285 ft. long on the Manhattan side and a section 100 ft. long on the New Jersey side. Each tube provides for a single track, and the two tubes are located on the same level and 37 ft. apart, c. to c. A typical cross-section of one of the tubes is shown by Fig. 10. As will be seen, the construction differs from that of previous cast-iron lined tube tunnels, principally in the great thickness and strength of the concrete lining. The main details and dimensions are given by the drawing.

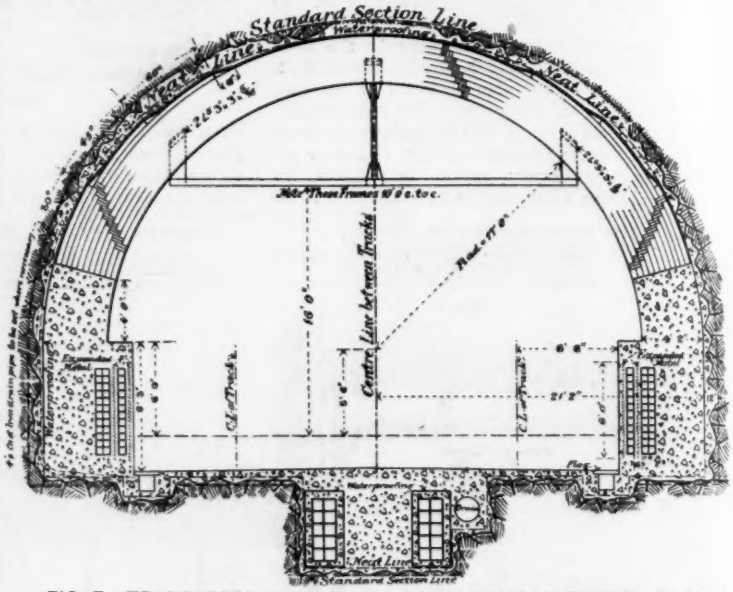

FIG. 7. TRANSVERSE SECTION OF DOUBLE-TRACK TUNNEL IN MANHATTAN.

TUBE TUNNEL WITH SCREW-PILE FOUNDATION.—The greater portion of the North River tunnel, some 5,502 ft., consists of parallel cast-iron and concrete tubes carried on a foundation consisting of 27-in. screw piles spaced 15 ft. apart. This is by all odds the most novel feature of the entire tunnel structure, and it is clearly shown by the cross-section, Fig. 11. In substance each tunnel consists of a cast-iron tube made very stiff by means of a heavy lining of concrete, which is carried on a row of piers, each composed of a single screw pile of large size. The structure is very simple; its construction, however, involves some difficult features. The following paragraphs relate to the tunnel structure alone.

The cast-iron lining for the tubes proper is of the ordinary type, except that where the screw piles occur a special segment is inserted. Each ring of lining is 30 ins. long and is made up of 12 segments, one being a crown or key segment, with an arc 12¼ ins. long, and eleven being body segments with arcs 6 ft. 5.6489 ins. long. These segments have flanges 11 ins. deep over all on all four edges. In the body segments the circumferential flanges are braced to the shell by triangular brackets 2 ins. thick, spaced about a third of the arc apart. The circumferential flanges have six bolt holes for each body segment, and the longitudinal flanges have five bolt holes for each segment. The connecting bolts are 1½ ins. in diameter. The segments are arranged so as to break joints longitudinally, and the key segment is, therefore, alternately right and left of the crown line of the tunnel. Full drawings of the cast-iron lining cannot be given owing to the restrictions of space, but the construction can be

fairly judged by the drawings of Fig. 12, showing the key segment, and those of Fig. 13, showing sections of longitudinal and circumferential joints in the body segments.

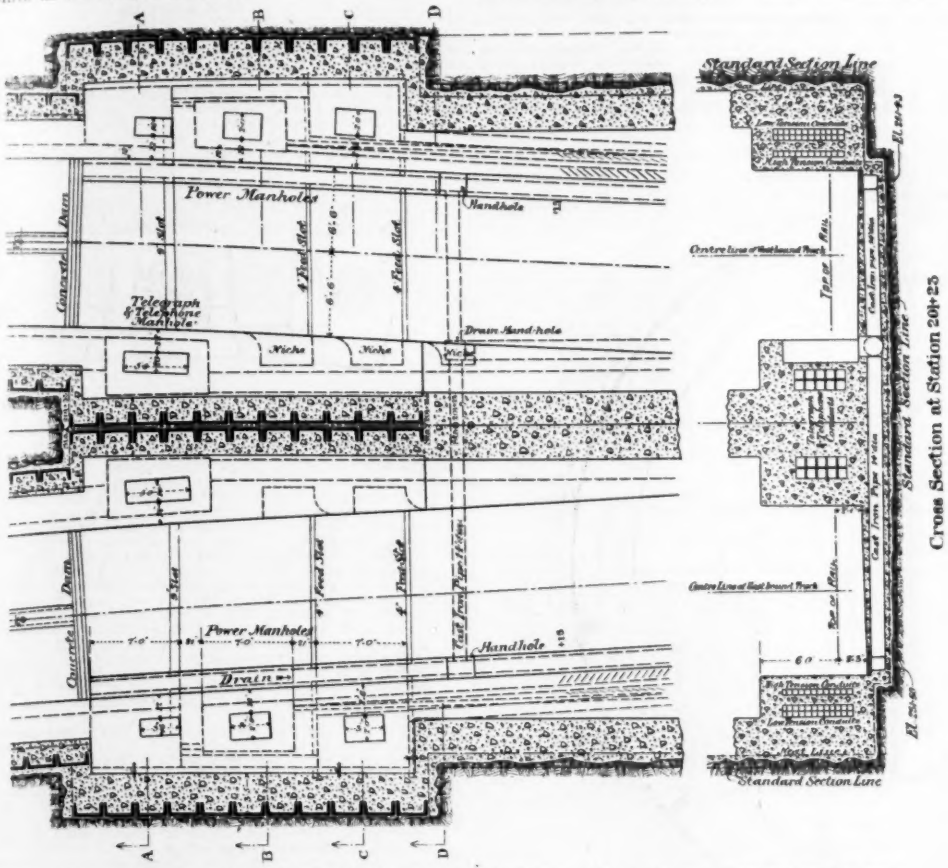

FIG. 8. PLAN OF MANHATTAN SHIELD CHAM BERS AND ADJOINING TWIN TUNNELS.

The bore segments through which the screw piles pass are of special construction, and are made of cast steel and in pairs occupying the width of two rings. These are placed at the bottom of the tube and are so located as to be exactly divided by the axis of the tunnel. Their construction is best explained by the detail drawings of Fig. 14, which show it to be rather intricate. The first thing to be noticed is that when the two segments forming a pair are placed together a circular hole 2 ft. 6½ ins. in diameter is formed in the bottom of the lining. This is for the accommodation of the shafts of the screw piles. To permit the passage of the blade or helix of the pile there is left a slot in the castings having the form and arrangement showing by the plan and various sections. To close the hole in the lining previous to its occupation by the pile a temporary collar and cast-iron plug has been designed. To fill the slot in the casting provided for the blade of the pile cast-iron fillers of the form shown in Fig. 14 are employed.

The screw piles on which the cast-iron tube is founded are of the usual construction except in a few particulars. The helix has one turn, with the usual lap, and a pitch of 21 ins. Fig. 15 is a vertical axial section of the cast-steel helix ring of the pile. The pile shaft is 2 ft. 3 ins. in outside diameter, and is composed of 7-ft. rings. The connection between successive rings is constructed as shown by Fig. 16. There are four flange bolts and twelve steel dowels occupying adjoining circular mortises drilled in the ring flanges. These dowels take the torsional strains resulting from the screwing down of the pile, and the bolts serve to clamp the adjoining sections of shaft together. Fig. 17 shows the dowel construction and the bolt connections in greater detail. One other point requires mention in connection with the screw-pile construction. It will be seen from Fig. 11 that the upper portion of the pile is enclosed in a sleeve. This is simply a sheet steel cylinder placed as shown when the pile has been driven down sufficiently to allow of it, and its purpose is to provide a sort of cofferdam in which the final 7-ft. length of pile shaft can be disconnected and lifted out, and in which another section of the exact length required can be inserted and connected up. It will be noted also that the top 12 ft. of the pile shaft is filled with concrete. The closing section of the pile shaft will vary in length and will have in each case to be built to measurements made after the pile has been driven to its final depth. Fig. 18 shows the construction of this section, with its cap C and adjustment rings A and B.

One other structural feature of the tunnel lining deserves special mention in this place. This is the expansion joint construction which will be adopted at or near the intersection of grade and rock lines to take up any lengthening or distortion that may tend to occur at such points owing to the difference of the ground in bearing material. This joint will consist of a ring within a ring, and these rings will be made of wrought steel instead of cast iron. A section through these rings parallel to the axis of the tunnel is shown by Fig. 19.

CONSTRUCTION.—The tunnel structure for the North River Section is intended to be constructed by means of shields and under air pressure. This circumstance and the unusual character of many of the structural features led the Board of Engineers to specify the general methods of construction in some detail. These requirements will be given here in abstract only, and the wording of the specifications will be quoted:

COMPRESSED AIR SUPPLY.—The air compressors shall be of sufficient capacity to deliver regularly into each heading at least 300,000 cu. ft. of free air per hour at a pressure of 50 lbs. per sq. in. above the normal air pressure and a larger amount if found necessary during the progress of the work. The air shall be delivered into each heading through two supply pipes of such capacity that the velocity of air through them in regular working shall not exceed 40 ft. per second. These pipes shall be tapped with regulating valves in each intermediate air chamber in tunnels and sufficient air admitted to ventilate it and to maintain the pressure required. If required by the engineer, air shall be delivered at the shield in each section or compartment thereof where men are employed, and withdrawn therefrom in special exhaust pipes with suitable regulating valves.

A foul air vent pipe 8 ins. in diameter shall be carried back from the shield through each lock bulkhead to the ordinary atmosphere to ventilate the heading and shall be provided with a 10-in. pressure regulating valve near the shield to maintain the pressure required. The amount of carbonic acid at any working face or in any chamber must never exceed one part in one thousand parts of air. When blasting is resorted to, special means must be provided for the rapid removal of the fumes produced.

BULKHEADS AND SAFETY SCREENS.—Bulkheads

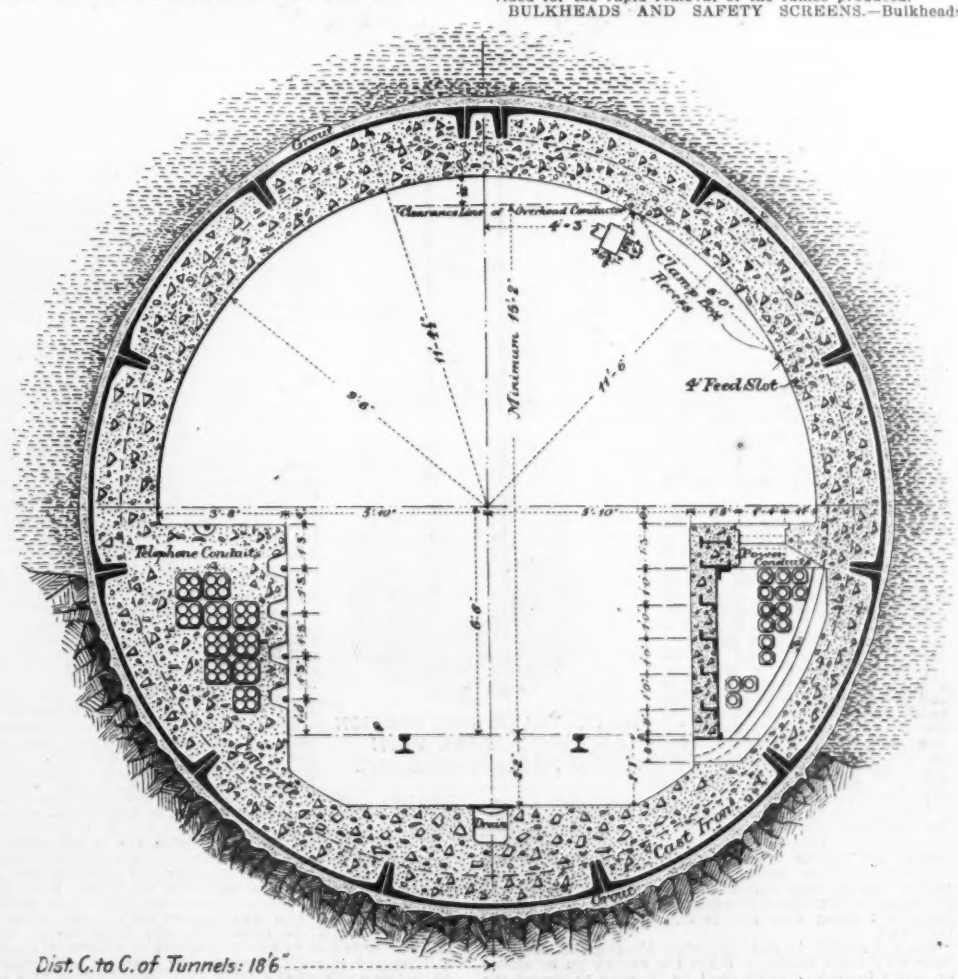

FIG. 10. TRANSVERSE SECTION OF TUBE TUN NEL WITHOUT FOUNDATIONS.

shall be built in each tunnel at intervals not exceeding 1,000 ft. and there shall at no time be an interval of more than 1,000 ft. between a shield and the bulkhead nearest to it. They shall be of concrete or of brick set in Portland cement mortar. Each bulkhead shall be provided with two air locks near the bottom at least 6 ft. in diameter and 20 ft. long for the passage of men and materials, one near the roof as an emergency lock for the passage of men only, and a pipe lock 12 ins. in diameter and 31 ft. long with a gate valve at each end for passing pipes and rails. The emergency lock shall be of ample dimensions to contain the entire force employed at any time at the heading. Stairways and galleries extending the full length of the forward air chamber shall always be maintained to give convenient access thereto and for the purpose of setting out lines and inspection. All parts of bulkheads and air locks must be of sufficient strength to sustain safely a pressure of 55 lbs. per sq. in. When a shield has been driven 500 ft. or more from the shield chamber, at least two bulkheads shall always be in use. No bulkheads shall be removed until a third one has been built and put in operation.

A safety screen extending from the roof downward into the tunnel shall be maintained within 100 ft. of each working face, and others shall be built at intermediate points between the working face and the nearest bulkhead if necessary to maintain a chamber filled with compressed air along the tunnel roof and give access to the emergency lock.

SHIELDS.—The shields must be of ample strength and of the best materials; must be provided with hydraulic rams of sufficient power to move them with facility along the alinement laid down on the plans and profiles and must have adequate arrangements for the rapid execution of the work and for the safety of the men employed therein. The contractor will be required to make use of the most effective devices in the construction and operation of the shields. Detailed plans and specifications of the shields, hydraulic presses, fittings and other appliances must be submitted to the engineer before beginning their construction, modified or amended if required by him. The shields are to be erected in enlarged sections of the tunnels (shield chambers) lined with cast iron. The enlarged sections shown on the contract drawings are of the least dimensions that will be permitted. Before moving the shield forward after erecting it, the standard cast-iron lining shall be built up temporarily within the enlarged section and within the tail of the shield to perfect shape, alinement and grade to start the permanent lining from and to form a thrust bearing for the shield.

When material is met requiring blasting, it shall be done with small charges. When the excavation is wholly or partly in rock, enough shall be removed to permit the forward movement of the shield on the established line and grade without coming into contact with the rock. The invert shall be leveled up with concrete formed to the exact grade of the required excavation and the exact form of the shield, to serve as a cradle therefor. If the engineer considers it necessary, steel rails or plates shall be laid to slide the shield upon. In driving the shield, no pressure shall be brought on the circumferential flanges of the lining segments.

CAST-IRON LINING.—The calking recesses between the flanges of the cast-iron or cast-steel linings shall be scraped out, cleaned and washed with a jet of water under a pressure of at least 50 lbs. per sq. in., and then calked with a cement of iron borings and sal-ammoniac mixed in proportions of 400 of the former to 1 of the latter, by weight.

Bolts and nuts for the joints of the cast-iron or cast-steel lining shall be of soft steel, forged from the solid, without welding, and the bolts shall project at least ⅝-in. outside the nut when screwed up in place in tunnel. Bolts shall be capable of bending when cold 180° flat on themselves without crack or flaw. When the bolts are firmly screwed up the bolt holes must be absolutely water-tight.

The engineer may require the contractor to supply cast-steel tunnel linings, where not herein specified, in lieu of cast iron.

EXPANSION JOINTS.—In each tubular tunnel at or near the intersection of grade and rock line, the contractor shall substitute for an iron ring of tunnel lining a ring within a ring, each of mild steel, forming a sliding sleeve to permit of any lengthening or distortion that may tend to occur there, owing to the difference of the ground as bearing material. It shall be kept water-tight during the progress of the work, and the subsequent period of maintenance provided for in the contract by means satisfactory to the engineer.

BORE SEGMENTS.—In placing the segments of tunnel lining, the cast-steel bore segments at the bottom through which the screw pile will pass shall be placed first and in perfect alinement and shape, and will be held in proper relative position by steel dowels, fitting accurately in drilled holes.

Cast-iron plugs formed in two pieces must be furnished by the contractor to temporarily fill the holes in the cast-steel bore segments through which the screw pile will be driven subsequently. These plugs will be considered a part of the contractor's plant. Each plug must be carefully placed and wedged up to transmit thrust uniformly around the tunnel lining. It will not be removed until immediately before the screw pile is to be placed.

SCREW PILES.—The screw piles are to be driven or screwed down through the bottom of the tunnel lining in correct position and at such times and places as the engineer thinks best in the interest of the work. They shall be driven to such depths as specified from time to time by the engineer, who may require them to be driven to bedrock. While the screw piles are being driven, they shall be loaded by hydraulic pressure or otherwise, in such manner and to such extent as the engineer may require. Each screw pile after driving shall be submitted to a test load to the satisfaction of the engineer by the hydraulic pressure or otherwise, previous to acceptance.

Where screw piles are driven to a comparatively shallow depth, the engineer may require the contractor to drive a sleeve, of somewhat similar design to the screw pile sleeve elsewhere described, down to the bedrock; the rock shall then be dressed off to give a solid and uniform bearing for the screw pile, and in such case the engineer may adopt piles without screw points. The material will be excavated from inside the sleeve and the screw pile shaft put down to the required solid foundation on rock and filled solidly with concrete.

As the lengths of screw piles cannot be definitely predetermined, it will be necessary to withdraw the top section of all screw piles and fix in its place a special section of the proper length. The contractor must provide for the delivery of these special sections within three days from the date of order, which will be issued as soon as the exact length required is determined.

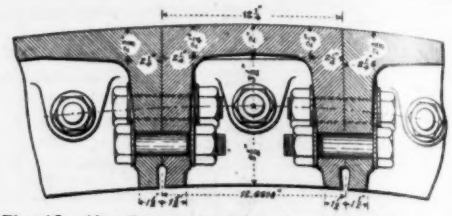

Fig. 12. Key Segment of Cast-Iron Lining for Tube Tunnel.

To enable the top section of a screw pile to be withdrawn and the special one substituted, a thin steel sleeve will encase the screw pile at the top to a depth sufficient to form a bulkhead to retain the ground during the operation. The collar or upper portion of the sleeve which is thicker will be turned to fit within the bore of the cast-steel segments. Previous to the setting of the sleeve, a temporary cast-iron collar will be furnished by the contractor as part of his plant, and will serve to guide the screw pile and maintain it centrally so that the sleeve collar may be easily placed in position when the screw pile is driven to a sufficient depth to permit it.

The head of screw pile at junction with cast-iron tunnel lining is to be made thoroughly water-tight, and the slot between tunnel segments for passage of screw blade is to be stopped with an iron "filler" casting and made water-tight by rust jointing.

It is assumed that the ground will rise within the screw piles to about the heads of same. This ground shall be removed in every case to a depth within the screw pile of 12 ft., and the screw pile filled with concrete up to the underside of the steel diaphragm plate. A wrought-iron pipe 2 ins. in diameter for grouting shall be built in the center of the concrete column, extending vertically through it. The steel diaphragm plate shall be bolted down and through the grouting hole in same and 2-in. pipe, cement grout shall be injected under a pressure of at least 100 lbs. to the sq. in.

The work of sinking the screw piles shall be done in compressed air, and as it probably cannot be done simultaneously with the driving of the tunnels with advantage to the progress of the work as a whole, the bulkheads in each tunnel shall be left intact, removing only and temporarily the drumheads or doors of locks, until compressed air between either of the bulkheads for the above mentioned purpose is again installed.

GROUTING.—Each segment of the tunnel lining shall have a hole near the center for grouting, which hole shall be closed by a screw plug. As soon as the engineer considers it practicable after a ring of tunnel lining has been placed and the shield advanced beyond it, the hole shall be opened and grout shall be forced into the surrounding materials by means of a suitable machine which will mix the grout continuously and permit the application of a pressure of 60 lbs. per sq. in. in excess of the external water pressure. Sufficient grout shall be used to fill all voids outside the cast-iron lining and to form a shell having an average thickness of 3 ins. Where the tunnel is driven wholly or partly in rock, the grout shall fill all voids between the cast-iron lining and undisturbed rock or concrete trough, whatever their extent may be. When the grouting is completed, the plugs shall be replaced and screwed up tight.

It is expected that the concrete lining with the conduits for electric wires, etc., will be placed after the removal of air pressure, but if the engineer considers it necessary

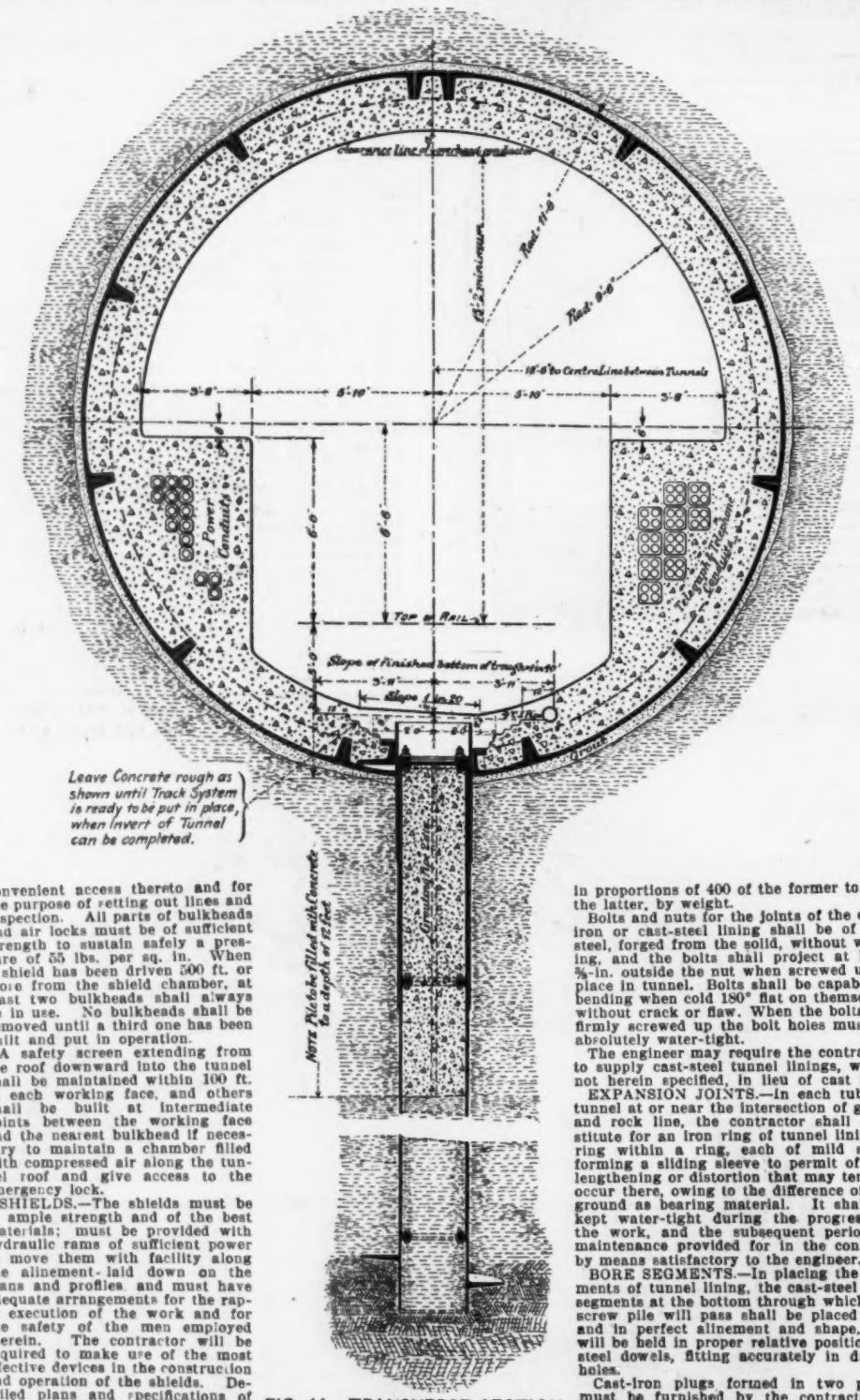
Clearance line of arched roof
Rad. 11'-9"
Rad. 9'-6"
15'-6" to Central Line between Tunnels
5'-8"
5'-10"
5'-10"
5'-8"
6'-0"
6'-0"
Power Conduits
Top of Rail
Slope of Finished Bottom of Invert
Slope 1 in 50
Ground
Leave Concrete rough as shown until Track System is ready to be put in place, when Invert of Tunnel can be completed.
Note. Pile to be filled with Concrete to a depth of 12 Feet

FIG. 11. TRANSVERSE SECTION OF TUBE TUNNEL WITH SCREW PILE FOUNDATIONS.

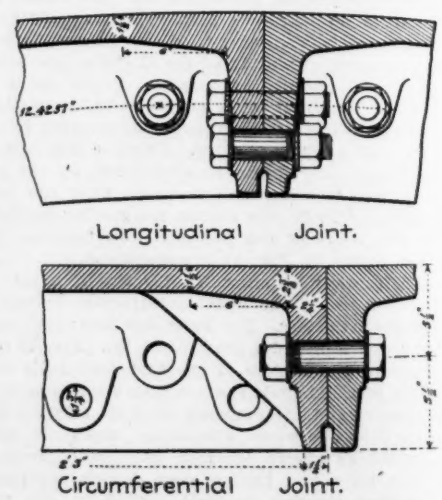

Fig. 13. Joint Construction of Cast-Iron Lining for Tube Tunnel.

in any case, the contractor shall place it in compressed air as the driving of the tunnel proceeds and as near the working face as the engineer may require.

Whenever required by the engineer, the contractor shall remove the air pressure in order to test the strength of the work, and if any weakness or break results, the contractor shall make it good at his own expense and in such manner as the engineer may direct.

The contractor shall provide, subject to the approval of the engineer, electric lighting for all parts of the work and plant, including lights for the Resident Engineer's office near the shaft and such special lights or groups of lights as the engineer may require in connection with surveys; telephone communication from each heading and lock to the power house and office of the Resident Engineer near the shaft; an 8½-in. air pressure gage at each lock bulkhead and on the 8-in. foul air vent pipe at each shield; a recording air pressure gage on each main between receiver and shaft, to be locked and the key kept by the engineer; elevators for lowering men and materials into and lifting them out of the shaft; suitable quarters near the shaft where the men can change their clothing, bathe and be warmed on coming out of compressed air; a compressed air hospital lock at the shaft at least 6 ft. in diameter, with two chambers where men can be subjected to the regular working pressure if attacked by caisson disease; suitable sanitary conveniences wherever the engineer may require, and competent medical attendance for the working force. The quarters for the use of men employed in compressed air shall be provided with hot and cold water, facilities for bathing, drying clothing, hot coffee at all times, and shall be continuously under the care of attendants specially employed for the purpose. The physicians shall have an office at the shaft as near the men's quarters as practicable, fully supplied with medical stores, and at least one physician with necessary staff shall always be present. The medical appointments shall be subject to the approval of the engineer.

The contractor shall employ no person in compressed air unless such person has passed an examination by a duly qualified physician in regard to fitness for such work.

The contractor shall install and maintain electrical or other mechanical haulage for the conveyance of spoil and construction material between the headings and shaft, or for the operation of other machinery in tunnels, the system being such as to emit no noxious gases. The use of horses or mules in compressed air will not be permitted.

If in the opinion of the contractor it becomes advisable, he may at his own expense deposit on the bed of the river or in a channel or channels excavated therein, blankets or masses of clay to reduce leakage of air from the tunnels; but no such measure shall be taken without the previous consent of the Secretary of War, and if taken shall be subject to such restrictions and regulations as the Secretary of War may impose.

NEW JERSEY LAND SECTION.

The New Jersey land section of the tunnel begins at the shield chambers on the Jersey shore and extends to the portal at North Bergen. This section of the tunnel is 6,290 ft. long, and it pierces the rock formations of Bergen Hill. Parallel single-track twin tunnels are planned. These tunnels are spaced 37 ft. apart c. to c., with a rock core about 11 ft. thick between them. At intervals of about 300 ft. a cross passage connecting the two tunnels is cut through the rock core, and at these points the cross passes are enlarged to form circuit broken chambers.

A cross-section of these twin tunnels is shown by Fig. 20. In this drawing the right hand figure shows the construction at cross passages, and the left hand figure shows the construction at manholes. As will be seen, the tunnel has concrete sidewalls and a brick roof arch, and is waterproofed on top and sides. The reinforced concrete front walls of the manholes will also be noted. The construction of these tunnels is governed by the same requirements as that of the tunnels of the Manhattan land section.

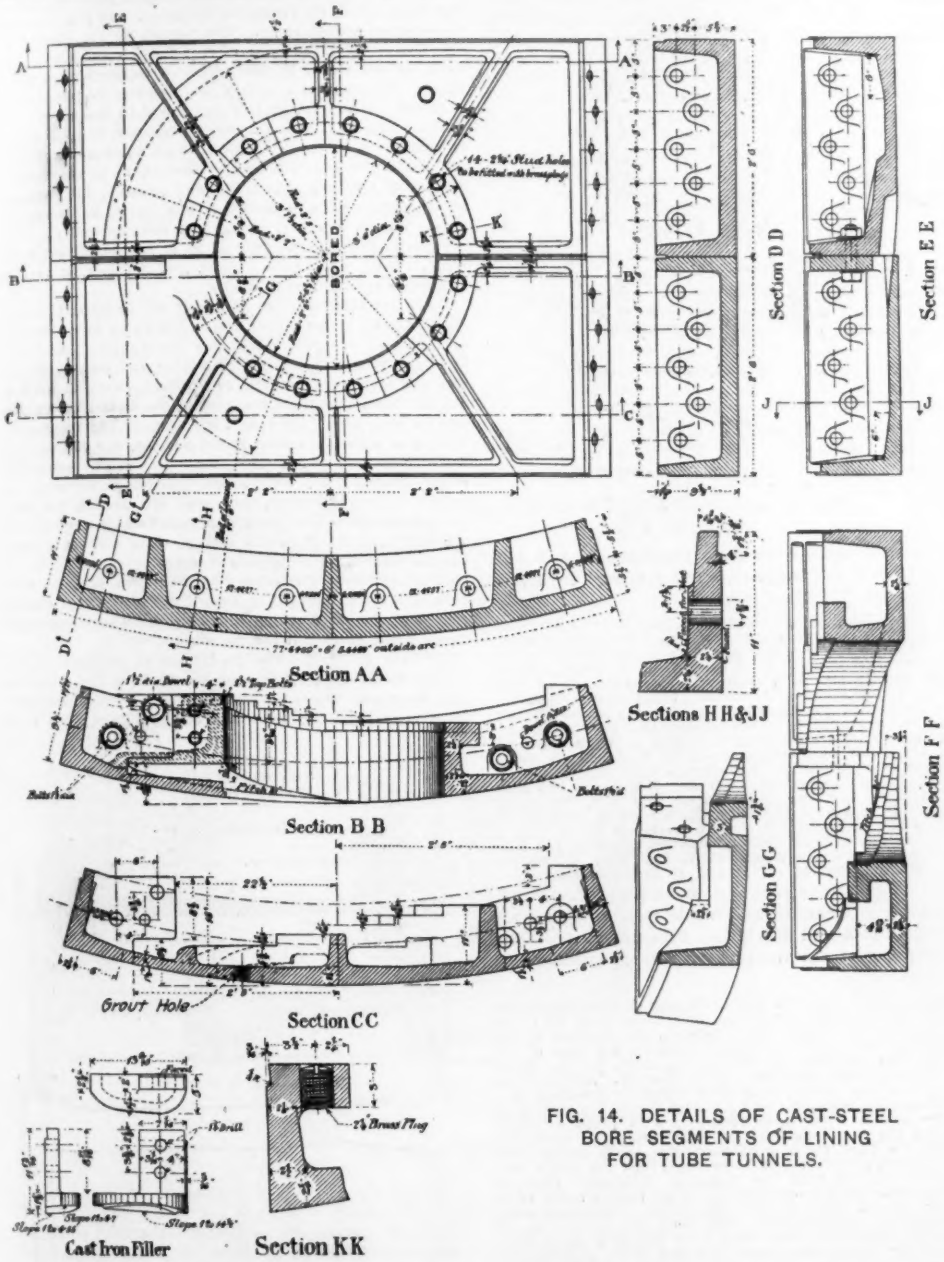

FIG. 14. DETAILS OF CAST-STEEL BORE SEGMENTS OF LINING FOR TUBE TUNNELS.

At North Bergen the tunnel emerges into a short open cut supported by retaining walls.

SHAFTS AND WORKING SITES.

For the construction of the tunnels of the North River Division a working site at Ninth Ave., and shafts at 11th Ave., and at Weehawken, on the Jersey shore, are provided for in the contract plans. The working site at Ninth Ave. is about 140 × 197.5 ft., and is a portion of the site to be occupied by the new Pennsylvania R. R. terminal station. This site is to be excavated and retaining walls built on the Ninth Ave. and 31st St. sides. From this site drifts are to be extended to the tunnel workings on 32d St.

The shaft at Eleventh Ave. is to be built by the company and turned over to the contractor for his use. It will be a side shaft, curbed with concrete and steel, and connected with the tunnel workings by two drifts. This shaft will be 30 × 22 ft. in plan, and the drifts will be 10 × 10 ft. each.

The Weehawken shaft will be on the line of the tunnel, and will be 130 ft. long. It will be a permanent shaft, with coped retaining walls, roof, stairways, etc., and the tunnels will connect with it by masonry portals. During construction one-third of the shaft will be used by the contractor for the Bergen Hill tunnels, and two-thirds by the contractor for the North River tunnel.

MATERIALS.

The materials used in the construction of the tunnel comprise as chief items concrete, brick and stone masonry, iron and steel castings, wrought steel and vitrified conduit. The character of these materials is very fully specified, and only a summary of the most important requirements can be given here.

Portland cement is required for all work, and is to be supplied to the contractor by the railway company. The tests of the cement will be very complete and will include the hot-water test for soundness. The sand is required to contain no more than 0.5% of "mica, loam, dirt or clay." For broken stone, gneiss from the excavation, if hard, crystalline and practically free from mica, may be used; otherwise broken trap or hard limestone is required. All broken stone has to be screened of all pieces smaller than ⅜-in. and all pieces larger than 1½ ins. The specifications for concrete work are abstracted as follows:

MORTAR, GROUT AND CONCRETE.—In proportioning materials for mortar, grout and concrete, one volume of cement shall be taken to mean 380 lbs. net, one volume of sand or broken stone shall be taken to mean 3½ cu. ft. packed or shaken down. Sand and broken stone shall be measured in barrels or rectangular boxes. Measurements in wheelbarrows will not be permitted.

In preparing mortar for brick or stone masonry, the specified amounts of cement and sand shall first be mixed dry to a uniform color. The water shall then be added in such a manner as not to wash out any of the cement and the mixing proceeded with until the mortar is thoroughly mixed and of uniform consistency. The proportions of cement and sand will generally be 1 to 2½ by volume, but when the work is wet the proportion of sand shall be reduced as required by the engineer.

Grout will generally be in the proportion of 1 part of cement to 1 part of sand by volume. The materials shall be thoroughly mixed dry and water then added while the mixing proceeds, until the grout is of the required consistency. The mixing shall be continued vigorously, preventing the separation of sand, until the entire amount mixed is used.

Concrete will be in the proportion of 1 part of cement to 2½ parts of sand and 5 parts of stone by volume, except in special cases where the engineer may require different proportions. For the upper portion of walls to a depth of 9 ins. below the surface and in narrow confined places, the smaller-sized stone specified (¾-in.) shall be used, and the proportions of sand and stone may be reduced to 2 volumes of the former and 3 volumes of the latter to 1 volume of cement. Whenever practicable the concrete shall be machine mixed; the mixing machine shall be a rotary mixer and of a pattern that will mix the concrete in batches and permit the definite measurement of the materials for each batch. When the engineer considers it impracticable to mix by a machine, it may be mixed by hand as follows: The mixing shall be done on a platform of boards or planks securely fastened together. The mortar shall first be made as specified. The broken stone, previously wetted, shall then be added and the mortar and stone turned over with shovels until the mortar is uniformly distributed through the mass and every stone is coated with mortar.

Where walls of concrete masonry exceed 6 ft. in thickness, masses of stone may be built in; such stone shall be clean, hard, compact and free from cracks or other unsoundness. They shall be set in at least 6-in. beds of concrete and have full bearings therein. They shall be set on their largest beds, shall be at least 6 ins. apart at every point, and at least 12 ins. from the face of the wall. No stone shall be more than 2 ft. in thickness. The large stones shall not in the aggregate exceed 15% of the total volume of the masonry containing them.

The degree of moisture for mortar, grout and concrete shall be at all times as required by the engineer or his inspector; in general, mortar shall be plastic, grout shall be fluid enough to be pumped, and concrete shall be of such consistency that it will quake when being deposited,

but not wet enough to cause the mortar to separate from the mixture.

Concrete shall be deposited in the work in such a manner as not to cause separation of mortar and stone. It shall be laid quickly in layers not exceeding 9 ins. in thickness, and thoroughly rammed with rammers of such form and material as the engineer may approve; special-shaped rammers will be required for corners and other places where ordinary rammers would not be effective. Compact, dense concrete must be obtained with all the voids between the stones filled with mortar. If voids are discovered at any time the defective concrete shall be removed and immediately replaced by concrete of such mixture and in such manner as the engineer may direct. Contraction joints in concrete formation shall be made where the engineer may require them. Where columns limit the thickness of "concrete" at face, the cement mortar used in conjunction with expanded metal lath is measured and paid for as concrete only.

When the placing of concrete is suspended, the engineer may require a joint to be formed in a manner satisfactory to him, so that the fresh concrete when added may have

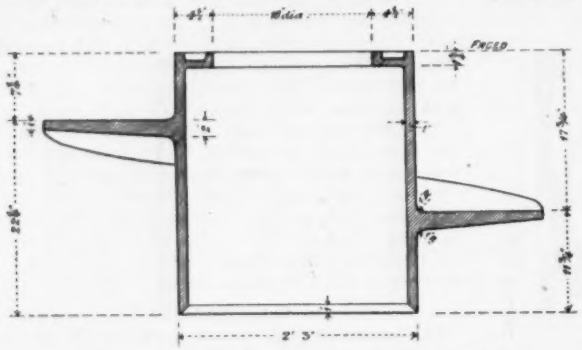

Fig. 15. Vertical Section of Point of Screw Pile.

a bond. Before depositing fresh concrete the entire surface on which it is to be laid shall be cleaned, washed, brushed and slushed over with grout of cement without sand. Water used in mortar, grout and concrete shall be clean, fresh water. No mortar, grout or concrete which has commenced to set shall be used anywhere in the work. Retempering of mortar or grout which has commenced to set will not be permitted.

Forms for concrete shall be substantial and must preserve their accurate shape until the concrete has set. Where the concrete will show in the finished work, the face of the form shall be built of matched and dressed planking finished truly to the lines and surfaces shown on the plans. Adequate measures shall be taken to prevent the adhesion of mortar to the forms. Forms which have become warped or distorted shall be immediately replaced.

Faces which will show in the finished work shall be true to the form intended, and shall be wholly smooth and free from ridges and cavities due to shortage of mortar at the face. Exposed faces shall have a facing of mortar 2 ins. thick, deposited simultaneously with the corresponding layers of concrete and separated from the concrete by a metal diaphragm of approved form. Immediately after the mortar and concrete have been deposited the diaphragm shall be removed and the materials well worked together by spading and tamping, so as to insure their bonding. In places where this method cannot be used, as the under surfaces of arches, the same end shall be attained by methods satisfactory to the engineer. Plastering the face after removing the forms will not be permitted. The facing mortar shall be of the same composition as the mortar used in concrete.

Rock surfaces shall be thoroughly washed and cleaned before concrete is deposited against them. Earth sur-

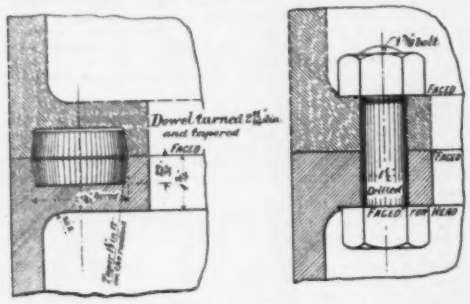

Fig. 17. Enlarged Detail of Dowel and Bolt for Screw Pile Shaft Connections.

faces shall be wetted and compacted by ramming immediately before depositing concrete thereon.

If leaks appear on the surface of the concrete at any time after removing the form the contractor shall remove the concrete through which the water passes and replace it with sound concrete, and shall stop the leakage or conduct the water to the floor of the tunnels through channels or pipes in the concrete or take such other measures as the engineer may require.

Brick and stone masonry materials and construction will be of high character, the specifications having all the requirements usual for first-class masonry work. The specifications call for vitrified conduits, glazed and smooth. These conduits are to be laid as follows:

The conduits shall be laid in about ¼-in. beds of mortar and in perfect alinement and grade throughout. The vertical joints between conduits shall be filled with mortar and the concrete carried up in layers as the conduits are laid. Dowels with central washer shall be provided by the contractor and placed in every dowel hole. A wood mandril 3 ins. in diameter at ends, 3⅜ ins. in diameter at the center and 4 ft. long shall be threaded through each hole after the conduits have been bedded in place, and the engineer may require the contractor to thread the mandril through a second time. A spring steel tube scraper with a flue brush behind it or other device approved by the engineer shall be attached to the end of each mandril and used to remove all foreign matter from the duct. Butt joints of conduits shall be broken at every tier half the length of the section, or as may be specially required by the engineer. Every joint of the four-way conduits shall be lapped around with two thicknesses and 6 ins. overlap of No. 6 cotton duck canvas 6 ins. wide, 3 ins. on each abutting section, saturated with neat cement grout immediately before placing. These laps are to be doubled on curves. Single-duct conduits are to be lapped on curves only.

One No. 8 B. & S. gage galvanized iron wire shall be placed, pulled and left in each duct from manhole to manhole.

Cast iron is required to contain not less than 10%

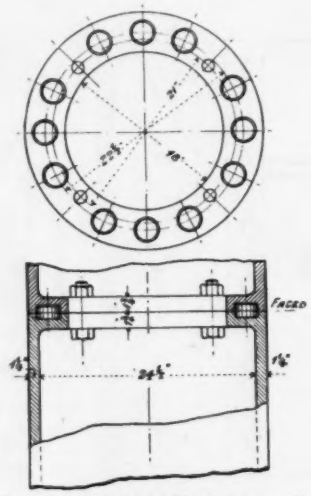

Fig. 16. Details of Shaft Connections for Screw Piles.

silicon, not more than 0.6% phosphorus, and not more than 0.13% sulphur. The required tests are as follows:

Test bars 1 in. square and 13 ins. long shall be cast and tested in their rough state. Four may be required from each ladle if the engineer considers it necessary, but if the operation of melting is carried on continuously not more than 10 sets of 4 each will be required from any cupola during a day of 24 hours. Three bars of each set will be broken by transverse test in a suitable testing machine, approved by the engineer, the load being applied slowly; the bars being sustained on knife edges 12 ins. apart and load being applied by knife edge midway between the supports. The average breaking load of 2 out of 3 bars must exceed 2,000 lbs. If the first two bars tested show that the metal passes this test, the third need not be broken. The fourth bar when resting on solid supports 1 foot apart must sustain 4 blows from a 10-lb. weight striking midway between supports, the first blow falling from a height of 12 ins., and subsequent ones from heights of 13, 14 and 15 ins. successively.

All castings are required to be dipped in metal pitch after cleaning and while still hot, and allowed to cool and dry before being machined. The machining of the lining segments is specified as follows:

All joints of cast-iron tunnel linings shall be planed to correct form and dimensions. Bolt holes may be cored and must be of the diameter required; the diameter of the bolt holes shall be ¼-in. greater than the diameter of the bolts. The thickness of the flanges shown on the plans is the minimum permissible after planing. After a segment has been planed, it shall be tested by applying substantial steel templates to all planed faces, the templates to be of the exact form required, with plugs attached having the exact diameter of the bolts, and sufficient length to pass entirely through the cored holes. The plugs must enter the bolt holes freely and the joints correspond exactly with the template. Whenever required by the engineer, the segments for at least three rings, after being planed, shall be bolted together, the rings lying horizontally, and when so connected the outer edge of either face of any ring shall vary nowhere more than ½-in. from a true circle nor more than ½-in. in length of circumference from the length required by the plans. The faces of the rings thus bolted up shall be true plane surfaces. Each segment shall be cast with a letter or figure to identify it.

On curves, either horizontal or vertical, taper rings shall be used, the tapers being formed by increasing the thickness of the flanges. The longitudinal joints shall be planed first; the segments forming a ring then assembled, firmly bolted together and circumferential joints machine faced. After planing, each segment shall be marked on one of the finished faces with figures cut or stamped showing the ring and position in same to which it belongs and its place therein. The segments of each taper ring shall be shipped together. A number of complete taper rings shall always be on hand at the work ready for immediate use. The faces of the bosses around the bolt holes shall be machine faced parallel to the plane of the finished joint. The spacing of bolt holes must be so accurate that any two rings of tunnel lining or screw pile section can be bolted together in any relative position.

Cast steel is required to have an ultimate strength of 70,000 lbs. per sq. in., an elastic limit of 40,000 lbs. per sq. in., an elongation of 15% in 2 ins., and a reduction of area at fraction of 20%.

The specifications for structural steel follow the best practice for high class bridge and structural work.

THE PRODUCTION OF ASBESTOS IN 1902.*

By Joseph Hyde Pratt.

The sources of supply of commercial asbestos are deposits of two distinct minerals; one is a variety of serpentine known as chrysotile, and the other is a variety of amphibole.

The amphibole asbestos is usually found in granitic or schistose rocks, sometimes in pockets, and again in well-defined veins. The chrysotile variety does not occur in a vein formation, but is in seams of varying width, which pinch out and widen, sometimes being thickly clustered together, and again occurring sparingly, and it is always found in serpentine rocks. The demand for the chrysotile asbestos is far in advance of that for the amphibole variety, on account of its being adapted to many more purposes. The amphibole variety can, however, be mined and prepared for market at less expense than the chrysotile variety, and as it makes a cheaper product there is some demand for it for those purposes where its nonconductivity of heat is the principal quality desired, as in the manufacture of fireproof paints, for wall plasters, for packing in the manufacture of fireproof safes and of boiler coverings. Where, however, strength of fiber as well as nonconductivity of heat is desired, as in the manufacture of cloth, ropes, felt, boards, tubes, and washers, it is the chrysotile variety that is used.

There are many sources of supply of the amphibole asbestos known in the United States, but owing to its limited demand and its small value, only those deposits that are the most favorably located for mining and transportation and are near a market can be profitably worked. When one considers that there are used in the United States per annum only about 1,000 to 1,500 tons of the amphibole variety of asbestos, valued at $16 per ton, one can readily understand how the market for this mineral could be easily oversupplied, with a corresponding decrease in price. Unless, therefore, new uses are devised for this variety of asbestos or there is a considerable decrease in the supply of the chrysotile variety, there will be a very limited market for amphibole asbestos.

Considerable development work has been done on this type of asbestos deposits in several different states during 1902, and a number of new companies have been organized to mine and prepare it for the market.

UNITED STATES.—The production of asbestos in the United States during 1902 was chiefly from the mines at Sall Mountain, White county, Ga., with smaller amounts from near Hinsdale, Berkshire county, Mass., the total

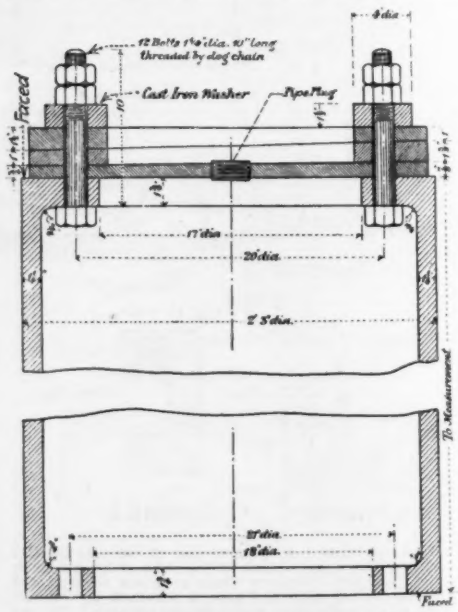

Fig. 18. Top Segment of Screw Pile with Cap.

quantity being 1,005 short tons, valued at $16,200. This is an increase of 258 tons in quantity and of $2,702 in value over the production of 1901, which was 747 short tons, valued at $13,498. Of this production all but a few tons was amphibole asbestos. In the development work of the Connecticut Asbestos Co. there were about 500 tons of asbestos taken out, but none of it was treated or placed on the market. The same is true of the Vermont deposits, although during 1901 it was fully expected that

*Greatly condensed from a bulletin of the U. S. Geological Survey, reprinted from the "Mineral Resources of the United States," 1902.

this asbestos would be placed on the market in 1902. The production of asbestos in the United States has never been over 1,200 tons per annum, and when these figures are compared with the amount of asbestos imported, which is almost entirely of the chrysotile variety, it will be appreciated how large is the demand for this variety.

In 1902 the total value of the imports of asbestos was $762,432, an increase of $70,604 over that of 1901, which amounted to $691,828. This in turn was an increase of $335,877 over that of 1900, which was $355,951, and illustrates the phenomenal increase in the demand in the United States for the chrysotile asbestos.

CANADIAN ASBESTOS.—Nearly all the asbestos imported into the United States is obtained from Canada,*

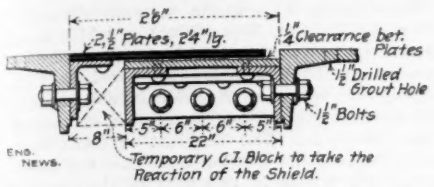

Fig. 19. Section of Expansion Joint for Tube Tunnel Lining.

and is of the chrysotile variety. These deposits are associated with the basic magnesian rocks mentioned above as extending from northern Alabama, in the United States, northeast to Gaspé Peninsula, in Canada. There are three distinct Canadian districts, all in the Province of Quebec, from 60 to 100 miles south and southwest of Quebec. One is in the vicinity of Danville; the second is near Coleraine, Black Lake, and Thetford, about 30 miles northeast of the first; and the third is near Broughton, about 15 miles northeast of the second. All these deposits have good railroad facilities, those near Danville being on the Grand Trunk R. R. and the others on the Quebec Central. There is still another district in the vicinity of Ottawa where asbestos occurs in limited amount, but it has not yet assumed any importance as a producer of this mineral.

several inches in length, is put on the market as crude asbestos, and is the profitable product of the mines. The percentage of this quality of asbestos in the rocks is very variable, and from 30 to even 90 tons of rock have to be mined to yield one ton of crude asbestos. Besides this, there is more or less very short fiber that is milled and sold as mill fiber or paper stock. The necessary removal of such a very large percentage of waste rock renders it necessary to economize in every way possible in the handling of this rock.

The general method employed for mining this kind of asbestos is by open cuts or pits, as in quarrying; the rock being worked out by benches as far as practical. In most cases drilling is by steam or compressed air, except in the smaller places, where hand drills are employed. Holes are drilled from 8 to 12 ft. and the blasting is only intended to thoroughly loosen and shatter the rock. It is then pried out with crowbars, and the pieces containing asbestos are broken by means of heavy sledges and steel wedges to such size that the asbestos can be readily broken out with small hammers. In the smaller mines the waste rock and asbestos are removed by means of a derrick, but in the larger ones cables are used. The asbestos is then transferred to a drying room, and when dry is hammered in order to separate as completely as possible all attached rock and also to separate the fibers. This material is divided into three grades, according to quality, which are known as No. 1 crude, No. 2 crude (white), and No. 3 crude (red). It is shipped in bags of 100 lbs. each. The remainder of the asbestos rock, which contains fibers from a minute fraction of an inch to about ½-in. in length is treated in the mills and made into mill fiber or paper stock. This material is first dried, then crushed to the right degree of fineness, and then passed into the "cyclone," where there is a nearly complete separation of the fibers from the rock. The fibers are thrown on the separating sieves, from which they are drawn away by exhausts. The rock, which during this process has been reduced to a sand, is ejected into bins. This still carries some asbestos, and it is beginning to be used in some quantity, being placed on the market as asbestic. The prices of these various grades of asbestos are about as follows: No. 1 crude asbestos, $150 to $250 per ton; No. 2 crude (white) asbestos, $75 to $125 per ton; No. 3 crude (red) asbestos, $50 to $75 per ton; mill fiber or paper stock, $20 to $40 per ton; asbestic, $1 to $3 per ton.

Intercepting the serpentine, with which the asbestos is associated, are masses and dikes of a granitic rock; and there is a relation to be inferred between the asbestos and these granite dikes. In nearly all cases where asbestos is mined, small seams or dikes of the granitic rock are observed cutting the serpentine. On one side of these granitic dikes the serpentine is hard and compact and contains very few and very small seams of the asbestos, while on the opposite side the serpentine is softer, less compacted, contains seams, and in some cases has strong indications of a shearing movement. It is in rock of this character that the asbestos seams are the largest and most abundant.

In this Canadian district the presence of the small granitic dikes is an aid in following the asbestos and should be of considerable assistance in locating favorable places to work from surface indications, if these granitic dikes outcrop on the surface.

The seams of asbestos vary from 1-16-in. to rarely 3 ins. in thickness. The fiber, which measures from ½-in. to

*The Canadian output in 1902, as given in a table covering a series of years, was 40,416 short tons, including 10,197 tons of asbestic.—Ed.

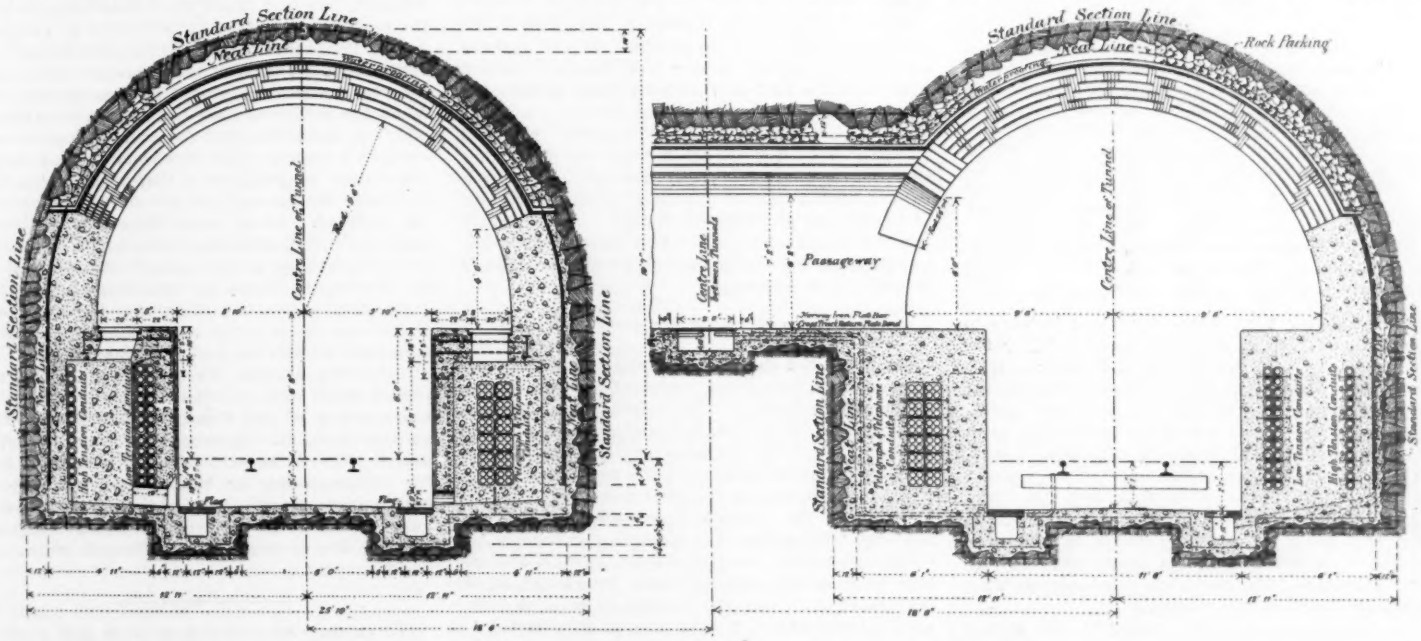

FIG. 20. TRANSVERSE SECTION OF TWIN TUNNELS UNDER BERGEN HILL.

REDUCING GAS LEAKAGE AT TIPPERARY, IRELAND.*

By John Patterson.†

Most managers with whom I have come into contact seem to spare no expense to acquire the latest novelty in retort settings, reputed to be capable of extracting an extra 100 cu. ft. of gas from each ton of coal carbonized, and at the same time of saving a few pounds of fuel, yet these same gentlemen are quite satisfied to continue losing from 10 to 15% of the gas they are making, and would grudge to expend a few pounds in overhauling their distribution plant. It is an accepted fact that dividends are made in the retort house, but it is equally true that often greater dividends are lost in the district. My personal experience at Tipperary has strengthened my conviction that a systematic test of mains and services, judiciously carried out, will repay the necessary expenditure in a very short time.

On being appointed to the management of the Tipperary gas works in April, 1898, I found that the unaccounted-for gas equaled 17% of the make; but as there were other matters in the works requiring immediate attention, it was not till the spring of 1899 that I had an opportunity of arranging for a systematic test. The method adopted was the bladder system, which consists in isolating a section of main by means of bladders, and with a test meter having a large dial, testing the soundness of the section under observation.

Having only a small staff, it was necessarily a slow process; and we only managed to get through half the district during the season. But the result, so far as we had gone, was very satisfactory, and was at once apparent; and when the accounts were closed for the year, there was an appreciable decrease in leakage.

The following season—viz, the spring and summer of 1900—was an exceptionally busy one for my outside staff, so that all hopes of resuming testing operations had to be abandoned until a more opportune time. However, we recommenced operations in the spring of 1901.

We experienced considerable difficulty in locating some of the leakages, owing to the porous and gravelly nature of the soil; but in most cases, by the aid of the steel bar, little difficulty was encountered. The net result of this systematic testing and general overhaul is shown in the following table:

	Unaccounted for gas	
	Cu. ft.	Percentage on make.
1897-98	1,729,000	17.00
1898-99	1,485,700	16.00
1899-1900	1,151,800	9.40
1900-1	1,361,600	9.60
1901-2	683,200	5.45
1902-3	474,700	3.50

Most of the leaks were traced to bad joints on mains, consequent upon hurried and defective workmanship, and to old and corroded service pipes. During the period under notice, we renewed 46 broken and corroded service pipes, and found about the same number of leaky joints—some small, and others very heavy leaks; in certain cases up to 25 cu. ft. per hour. Of fractured mains we only found three; so it is quite apparent that, given well-laid and properly jointed mains, our greatest source of loss was through defective services.

In order to reassure any who are reluctant to undertake a systematic test, owing to their mains being very old, I may mention the fact that some of our mains in Tipperary are upwards of 50 years old, of small diameter, and laid very shallow; yet, strange to say, these were found to be practically tight, while the greatest number of leakages were found on the more recently-laid pipes.

Old and defective meters, are, I feel satisfied, to a great extent responsible for a fair percentage of unaccounted-for gas. Gas meters are, after all, mere mechanical appliances, and liable to go wrong at any time; yet how many gas companies or corporations make it a rule to test their meters periodically? In Tipperary we test every meter when it has attained its tenth year, and the gas saved by so doing more than warrants the expense incurred in the removal and testing.

*Abstract of a paper read before the Irish Association of Gas Managers.

†Manager Tipperary Gas Co., Tipperary, Ireland.

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We give up a very large space in this issue to the details of the great tunnel to be built by the Pennsylvania R. R. under the North River at New York city. This is the hugest piece of engineering work in point of cost now in progress in this country, if not in the world. It is also the most extensive and difficult piece of submarine tunnel work ever undertaken. For nearly two years a large staff of engineers, headed by men who stand in the front rank of the profession, have been engaged upon the preparation of plans for this work, and the complete drawings, prepared for contractors' bids, attest the thoroughness with which the work has been done.

For a long time to come, probably, this tunnel will represent the high-water mark of achievement in submarine tunnel construction, and the methods there adopted will constitute a most important precedent. We have therefore deemed it fitting to give it an amount of space that we seldom accord to the description of any single engineering work.

Since the publication in our last issue of particulars concerning the Danville wreck on the Southern R. R., we have learned that the curve on the trestle approach where the derailment is said to have occurred was of about 10° and was a plain curve without a spiral or transition approach, also that the trestle floor had neither guard timbers or inside guard rails. We believe these facts are of sufficient interest to engineers to deserve particular attention. This wreck occurred on the main line of one of the most important railways of the country, over which many heavily loaded fast passenger trains are run every day. Because the accident occurred to a mail train carrying no passengers, and those who lost their lives or limbs were employees, it has attracted comparatively little attention; yet to an engineer an accident should be equally instructive, whether the casualties from it be great or small.

We wish to call particular attention to the absence of any transition curve at the point where the accident occurred, in connection with the statement that the derailment was caused by the breaking of a flange on the engine truck wheel when it struck the curve.

The common argument for the use of transition curves is that they make a smoother riding track. Is it not also a fact that they decrease the danger of fast running, particularly with modern heavy rolling stock? Who can estimate the stress which comes on the flange of the leading outside wheel of a car or locomotive truck when it strikes a curve at high speed? We know that that flange must do the work of setting the track for the curve; or in other words, it must force the truck around on the center plate until its axis makes an angle to the car body corresponding to the degree of the curve. If the curve has no transition approach, this setting of the truck for the curve must be done practically instantaneously, and the truck goes around with a jerk and a blow; if the track is laid with transition curves, the setting of the truck for the curve is done gently and gradually as the truck moves over the spiral approach, and the same smooth and gradual motion occurs as the truck passes from the curve to the tangent at the other end.

Of course, the common argument in the railway service is the argument of conservatism. It is said that railways have been successfully operated since the beginning of the railway era without the use of transition curves, and it is, therefore, argued that their use is an unnecessary refinement.

Such an argument, however, overlooks the changes which are taking place in the railway service, the higher speeds and heavier rolling stock, and the fact that with all these changes the wheel-flange—that slender rim of iron on which depends the safety of every traveler by rail through every rod of his journey—is no thicker now than a quarter of a century ago, and indeed, cannot without great difficulty be made thicker. If by the use of easement curves, we can reduce the shock and strain on wheel flanges, no argument should be needed to prove that the change is well worth making.

We doubt not that many of our readers will remember the interesting series of papers on the engineering schools of the United States, written by the late A. M. Wellington, and published in Engineering News eleven years ago. At the conclusion of this series of articles the practice was begun of publishing at frequent intervals items of news from the various institutions under the heading: "Notes from the Engineering Schools."

Beginning with our last week's issue, a change has been inaugurated in this long-established feature of this journal. Inasmuch as it is composed of matter which is of current interest chiefly and not important to permanently preserve like the technical articles in the body of the paper, it has been transferred to the Supplement, where it has been made a regular department, and placed next to the departmnt of "Engineering Societies."

As an example of the class of matter which we hope to present in this department, we may cite the very interesting statement which we print this week from President Alex. C. Humphreys, describing some of the changes which are being made at Stevens Institute, with the opening of the new year. Such reports from an engineering school are not only full of interest to the alumni of that institution, but are of practical value to all those engaged in the work of engineering education. We hope to make this department a means for the interchange of information regarding new methods of instruction and training, which will be of direct service to officers and instructors.

It is probable that at the present time there are in the United States not less than 20,000 students in the engineering schools of collegiate rank; and if we allow only one teacher to each 20 students—a very low estimate—at least a thousand teachers, most of them educated engineers, are engaged in their instruction. Certainly [illegible] the work which this great number of men is doing there is much deserving record and publication for the benefit of others engaged in similar work. We cannot of course take space to record the mere local news, such as finds a place in the journals which the various institutions publish, but we shall be glad to record such advancement as is of general interest to those engaged in similar work in other institutions.

The Clinton Ave. grade crossing disaster in Newark, N. J., on Feb. 19 last, in which an electric street car crowded with school children was struck by a Lackawanna express train, has had a widespread influence in molding public sentiment toward the compulsory separation of grades at such crossings. The accident in itself was no worse than other similar ones that are reported every few weeks in one part of the country or another; but it was so close to New York city that it gained wide publicity in the metropolitan newspapers, and the spectacular indictment of certain financial magnates among the street railway company's officers served to particularly attract the attention of the public.

Recently another accident was narrowly averted at this same Clinton Ave. crossing, and the occurrence is quite as instructive and quite as strong an argument against "the deadly grade crossing," as was the fatal disaster of last February.

It appears that a heavily-loaded electric car, its platforms crowded with school children, passed safely over the crossing and began to ascend the hill on the other side. It had gone only a short distance, however, when from some cause or other the power gave out. The motorman attempted to put on the brake to hold the car, but found to his consternation that the brake would not operate. The car came to a stop and then started back down the incline toward the Lackawanna tracks, where a train was just due, and the gates were already lowered. The motorman called to the passengers to jump, and there was a headlong exit from the car as it moved slowly back toward the crossing. At the same time the gate tender signalled the approaching train, which fortunately was not running at high speed, and by applying the emergency brake, the engineer brought it to a standstill a few feet short of the crossing, over which the electric car had just passed, having smashed through the crossing gates.

It will be evident that the derailing switches (which have been installed at this crossing since the accident of last February) are no protection against such an occurrence as that described above. It may be said with truth that the need for better brakes or better attention to brake maintenance is plainly indicated; but the larger lesson seems to be the wisdom of absolutely prohibiting the crossing of electric and steam railways at grade.

Where railway cuts are so deep that a rotary snow plow will not throw the snow clear of the cut, the upper portion of the cut may be widened so as to provide a berm that will catch the snow from a rotary plow. On the Oregon Short Line R. R., as described elsewhere in this issue, several long snow sheds in deep cuts have been dispensed with by thus widening the upper part of the cuts. It is not merely the first cost of a snow shed that makes it objectionable, but the cost of periodic renewals. Moreover, on any road where tourists form a large proportion of the passengers carried, snow sheds like tunnels are decidedly objectionable; and while it is not possible to weigh this objection in dollars and cents, it is well not to lose sight of any factor that may tend to give another route the preference in the eyes of those who travel for pleasure.

As passenger traffic increases, factors of this kind assume greater importance. Thus it is not to be doubted that hundreds of suburban dwellers near New York city can not be induced to live where they would be compelled to pass through a tunnel twice a day in going to and from the city. Much of this perhaps unreasoning antipathy to tunnels may be overcome by proper

lighting of the cars, but it may often be a cheaper plan and it always is a surer plan to obviate tunneling entirely. Deep cutting has been particularly objectionable on account of snow accumulations; but, if this objection may be readily removed by providing a berm to hold such snow as falls upon the roadbed, it is apparent that with the use of rotary snow plows, tunnels may oftener be omitted than has been the practice in the past.

The paper describing the standardization of drawing-room practice at the works of the Westinghouse Electric Co., printed in this issue, is one of the most valuable and interesting contributions to the literature of that department of engineering work that has appeared in a long time. It is undoubtedly true that the drawing room and its methods have been in many cases neglected by establishments which are otherwise in the forefront of progress. This is not so strange, however, when it is recalled that the use of mechanical drawing in connection with manufacturing industry is a thing of comparatively recent development, and also that up to a comparatively recent period there were very few works which had occasion to employ more than a small squad of draftsmen. Naturally, when the employees of a drafting room are numbered by hundreds, an amount of system and stardardization becomes necessary that would be needless red tape in a place where only a half dozen draftsmen or so were employed. It is a fact, however, that in some establishments the drawing room has been enlarged to great proportions, and yet the same primitive system or lack of system prevails as in the day of small things. It is in such places that study of Mr. Follows' excellent paper should be particularly helpful.

CONCERNING THE BUSINESS SITUATION.

The great staple crops of the United States will be this season of highly satisfactory volume and will be sold at good prices. The wages and the purchasing power of labor throughout the country has never been at a higher mark, and there are few men out of employment. All these conditions make for a continuance of business prosperity; yet men fix their eyes on Wall Street, the financial barometer of the country, and what they see there fills them with foreboding.

It is said, on the one hand, that there is no reason for such foreboding; that the buying and the selling, the production and consumption of the great commercial staples will go on just the same without regard to the bulls and bears of the Street. Others foresee in the Wall Street situation the beginning of a wave of financial depression, which will bring to a close the long period of prosperity that has ruled for five years now, and they prophesy a gradual extension of the depression to all classes of business. What depth this depression may reach, time only will disclose; and it cannot be doubted that the good crops of this season and the general prosperity of the masses of the people will be a great and most beneficial factor in relieving the situation. That we are at the end of the boom and entering on a period of diminished demand and falling prices, however, seems to be generally agreed by all intelligent observers.

The question asked on every hand is, why has the financial situation changed? No great failures have occurred such as precipitated disaster in 1873. The currency situation, if not satisfactory to everyone, is at least such that financial depression can in no wise be laid at its door. There is no fear of serious political changes to upset the general course of business. Where then shall we look for the source of the present clouds on the horizon?

The answer to this question is a simple one, and it is also reassuring. The real key to the situation is that in the market for capital, demand has outrun supply. There is at present a greater demand upon the world's capital than can be met by the supply of capital available.

In most periods of financial depression in recent times, this situation has arisen from other causes than those now at work. The failure of a great banking house, for example, such as that of Jay Cooke, in 1873, or the Barings, in 1890, destroyed business confidence, or, in other words, made capitalists wary about investing their money, and this caused the supply of capital to fall below the demand. At other times the absorption of capital, in unproductive enterprises, has exhausted the supply of capital and brought on a period of depression.

Neither of the above causes, however, has contributed materially to the present situation. All signs indicate that the real diagnosis of the disease—if it can be called a disease—is simply, too rapid expansion. Enterprise has made a greater demand for capital than there is capital available, and, consequently, a halt has to be called for a time.

To some it may seem strange that in this era of enormous fortunes, and widely distributed wealth, there can be such a thing as scarcity of capital; but it may be readily understood by remembering that the capital available for investment in any given period comes not from the accumulated wealth, but from the surplus income —the savings from the earnings which are made during that period.

A man may have a fortune of a million dollars invested in stocks and bonds and houses and lands; but he has no money to invest except as these properties yield him an income greater than he requires for his regular living expenses. He may, indeed, sell some of his property and invest elsewhere the money thus obtained, or he may borrow money; but he can only do either of these things by selling to or borrowing from some one else who has saved money out of his income. The only source, therefore, of new capital for investment is from the savings of the people.

It is of interest to note in this connection that one cause of the present financial situation is the growth of habits of luxury and expensive living during the past five years of prosperity. The farmer, the laborer and the capitalist have all had larger incomes during the years from 1898 to 1903 than during the four preceding years; but it is not at all probable that their savings have been in proportion. Money that comes easily goes easily, runs the old saying, and there are abundant of examples of its truth to be found from one end to the other of the social scale.

The chief cause, however, of the present situation is unquestionably the enormous amount of capital which has been absorbed by nations, states and municipalities, and by railway and manufacturing industries during the past four years. During that time the United States has carried on the Spanish War and the conquest of the Philippines, and has absorbed in the process several hundred millions of dollars. Great Britain in the same period has fought an enormously costly war in South Africa, and has made a huge addition to her national debt, thus absorbing capital that would otherwise have been available for industrial purposes.

Germany, during the four years from 1897 to 1901, engaged in a vast array of enterprises, particularly in the electric lighting and electric railway field, and made such inroads on her supply of capital that two years ago it became no longer possible to continue the expansion process, and financial depression has since prevailed there.

In our own country our cities have been enlarging their systems of water supply, drainage, lighting, street railways, electric lighting and paving, and in both city and country a great amount of building construction has been carried on. Every one of these works, great or small from New York city's $50,000,000 Rapid Transit Ry. down to the smallest piece of street work or dwelling-house construction, means the absorption of capital—the expenditure of money saved by some one out of income.

If we turn to the manufacturing industries we find a record of expansion even more phenomenal. During the four years prior to 1898 American manufacturers were chiefly concerned in finding a market for their product, so as to keep their establishments from shutting down. With the sudden revival of business in 1898, profits increased and manufacturers began to enlarge the capacity of their plants by the purchase of new equipment and the erection of additional buildings. Later, as confidence increased, the erection of entirely new works began. The trust epidemic gave a further stimulus to the building of manufacturing plants. Owners of factories would sell them to a trust-promoting syndicate at a high price and immediately go to work to build a new plant. There is hardly a line of manufacturing industry in which the present capacity of production is not greater by from 20 to 40% than it was in 1898, and this means that many hundreds of millions of dollars of capital have been expended during that time on buildings and machinery.

In the railway field, again, while capital has not been expended in additions to railway mileage to any such extent as in the '80's, it has been absorbed in much greater degree in the betterment of existing lines. Terminal improvements, elimination of grade crossings, lowering of grades, replacing wooden structures with steel and masonry, double-tracking, enlargement of yards, and installation of signals are among the expenditures of the permanent way department by which great sums have been absorbed. In the rolling stock department, many millions have been devoted to the purchase of heavier locomotives and freight cars of large capacity.

All these expenditures that we have enumerated of railways, manufactories, cities and states have had to be provided for from the surplus earnings of the people, saved for investment. This is true even when such expenditures have been provided for out of a corporation's own earnings. If a railway pays for a new bridge, for instance, out of its earnings instead of out of an issue of stock or bonds, it does so merely by taking money which otherwise would go to stockholders in dividends, and is just as much savings from income as if it had been contributed by the stockholders directly.

It is surely not strange, when one recalls the magnitude of the sums which have been absorbed during the past four years in the ways we have enumerated above, that the supply of free capital seeking investment has been greatly depleted, and that difficulty is now experienced in finding capital for new enterprises.

It is worth noting in this connection that the great fall in stock market prices is partly accounted for by this condition that we have explained. The price of capital, or, in other words, the rate of interest is fixed like other commodities by the law of supply and demand. The demand for capital by those willing to pay a high price for it has caused owners of securities which at the stock market prices of a year ago netted only 3% or less to sell them in order to invest their money to better advantage. Of course the fall in securities has also been fostered by lack of confidence in business conditions, distrust of the management of corporations and trusts, anxiety over the labor situation, and particularly by the forced sales of speculators who were compelled to raise money to meet maturing obligations. It remains true, nevertheless, that capital can command a higher price than a year ago, and that as a result a stock or bond earning a given rate of interest is actually worth less money to-day, and therefore ought to sell at a lower price than a year ago.

The engineer or contractor may deplore the fact that opportunities for business are falling off because of the difficulty of finding capital; but the fact must be recognized that the higher price of capital is the natural method of restoring equilibrium. It will and in fact already has caused the indefinite postponement of a great amount of projected work, and thus tends to reduce the demand for capital. At the same time, the fact that money brings a higher rate of interest, coupled with the general feeling that the times demand a return to more economical living, will cause people to save a larger portion of their income and thus will tend to increase the amount of capital available for investment.

Undoubtedly the recuperative power of the country is greater now than ever before. The capital absorbed in such huge volume during the past four years has, with the exception of that spent in wars, mostly been invested in enterprises which will themselves yield a profit under

normal conditions, and thus will serve to swell the fund from which new capital is derived.

It must be entirely clear, however, that henceforward the expansion process must be conducted with such capital as is available in the country's annual surplus. There is no great store of idle capital accumulated and awaiting investment now as there was in 1898, after four years of liquidation, economy and debt paying.

We have in the United States a great and prosperous country wonderfully supplied with natural wealth and blessed with a safe and stable government. Every year from the industries of this country there are produced earnings sufficient for all current necessities and a surplus besides amounting probably to many hundred million dollars, available to supply the demand for additional capital. It is to this source—to the annual increment of deposits in savings banks, life insurance companies and similar repositories, and to the surplus income of men of wealth, that we must look fo the supply of capital necessary to meet the demands of industry during the years to come.

No analysis of the present situation would be complete, however, which failed to note the well-known tendency of one extreme to follow another in such matters as we are discussing. Retrenchment once started is not easy to check. Expansion has been going on at an abnormal rate for four years past, particularly in the field of manufacturing. The endeavor has been made to supply the demand for manufactured goods in years of prosperity, and it is certain that with the falling of in demand which accompanies a period of depression, some of these mills must stand idle, or run on part time.

Idle mills mean idle operatives and reduced purchasing power. The stoppage of the building of new mills means a reduction in demand for materials and machinery. These are things not pleasant to contemplate; but it is as certain as anything can be that in finance as in mechanics action and reaction are equal and opposite. If we have built in recent years mills and factories more rapidly than the growth in demand warranted, then sooner or later we must pay the penalty for such over-rapid expansion by halting construction for a time until the market demands will again enable new works to be employed.

It is a fortunate thing in reference to the present situation that business confidence has not been impaired. Speculation has indeed been checked, and the promotion of over-capitalized trusts has come to a stop, but there has been no general collapse of credit, and with the warnings which have been so evident for a year past, none need be expected. The danger at the present time is that we shall swing from one extreme of the pendulum to the other; and that instead of continuing the work of expansion as fast as new capital becomes available, a season of distrust will succeed the season of over-confidence and we shall see a dearth of new enterprises and capital lying idle for lack of safe opportunity for investment.

Four years ago, in discussing in this place the question, "How Can We Make Prosperity Stay?" we said:

> The way to make the good times stay is to hold in reserve a part of the forces which are now pushing the tide of prosperity on toward its flood, that they may be expended later to check the ebb.

We urged, in other words, that the period of prosperity was the least favorable time to invest capital, since with labor and materials scarce and high priced, the cost of the work was sure to be largely increased over its cost in dull times.

Conversely, at the present time, the outlook is more promising for the profitable investment of capital than during the past four years. Materials of construction are lower and wages are pretty certain also to fall, when the alternative of no work at all is faced. A city, a railway company or a manufacturing concern can undertake works at the present time with better prospect of completing them below the estimate than for a long time past. This well understood condition is likely to play a large part in relieving the business situation and preventing the serious results that have occurred during some periods of financial depression.

LETTERS TO THE EDITOR.

The Desirability of a Means of Making Sun Prints From a Print.

Sir: We notice in your issue of Oct. 1 a letter on "Making Sun Prints from a Print." Does "Engineer" mean to use thin brown paper to make the first print, or to take prints from the first one? If the first proposition, the suggestion is of little value as ordinarily the party wishing to reprint from the blue-print has no control over the paper used the first time.

We very often are required to carry out details that are shown by only one blue-print furnished to us; yet there may be half a dozen kinds of work required to come from as many different factories. A means of making further prints from the one furnished would be of great value.

Respectfully,
Bartlett & Kling.

Galesburg, Ill., Oct. 6, 1903.

More Concerning Large Plate Eye-Bars.

Sir: Your remarks on p. 320 of your last issue appended to my comparison of eye-bars and plate-links are based on misinformation, and therefore I write to give you some more facts about eye-bars which you seem to have overlooked.

Plate-links and eye-bars will have identical dimensions in every particular.

An eye-bar does not dish when packed as in a bridge chord; plate links of exactly the same dimensions will not dish any more.

Eye-bars have from 25 to 40% more metal across the pin hole than the body of the bar, the bar and head being of uniform, identical thickness.

Plate-links will be identical in these particulars. If your readers will try strips of paper, as you suggest, and pack them as eye-bars and plate-links would be, on pins, head against head with washers and nuts on the outside, they will learn that these paper eye-bars will not dish.

Your assumption that steel plates are much stronger in a longitudinal direction than transversely is again an erroneous assumption. In thin steel plates there is a slight difference, as you suggest; in thick plates or bars of steel such as are used in bridges this difference disappears entirely.

Again, if you had had the writer's experience in testing materials you might perhaps realize that the riveted joint tests referred to were true plate tests; the joints were not affected because they were so thick and contained so many rivets that their strength was not at all determined or tested as not one of them failed. To test the actual strength of a joint it must be so designed as to make it possible to determine under which loads it would fail. All that these tests proved regarding the joint was that it was what it should be—stronger than the plates it was supposed to connect.

As the necessary milling machines would be a permanent investment in any bridge shop, their total cost cannot be charged to expense or cost of making the plate links; all that should be charged against the cost of making them is interest on capital invested, depreciation, cost of power required to drive them and labor.

You are mistaken in saying that "45% of the plates had to be discarded."

The metal cut from both sides of a plate 45 ft. long by 42 ins. wide required for an 18-in. plate-link or eye-bars would be two bars of the thickness of the plate about 12 ins. wide and at least 36 ft. long. Bearing this in mind you may perhaps realize that such plates are merchantable material and would fetch in course of time as much per pound as the original plates did. Proportions of width of heads and bars are such that in every case of making links similar marketable bars would be cut off as waste.

The writer made no attempt to "indict American practice in the use of forged eye-bars;" all he did was to try to point out to American engineers the relative qualities of eye-bars and plate-links, and the real economy of the latter as demonstrated by the construction of the first large bridge for which they were made by modern methods.

Yours truly,
Gus. C. Henning.

275 Water St., New York City, Oct. 8, 1903.

Are Y's Ordinarily Included in the Linear Measurement of Sewer Pipe.

Sir: What is the general custom in paying for Y branches in pipe sewers?

A contractor has told the writer that the pipe is measured straight through from one end to the other and paid for; and that each Y branch is extra, at the prices bid, unless it is explicitly stated that the price for pipe includes Y's.

In one city in this country, however, a contractor who bid for "Sewer pipe furnished and laid," and for "Y branches furnished and laid," is held up on payment for his work because the engineer figures the special containing the branch as the branch, and allows nothing for the 2 ft. of straight sewer attached to the branch.

There was nothing in either the call for bids or in the specifications to indicate that such a ruling would be made. Consequently the prices bid for Y's are low—in some cases less than cost of the 2-ft special containing the Y.

If the engineer intended making such a ruling would he not have stated, "Specials containing Y branches furnished and laid," instead of wording it as he did?

Yours truly,
Reader.

Oct. 8, 1903.

[Replying to our correspondent's first query, it is the general custom to measure the length of sewer pipe from center of manhole to center of manhole, without deducting for the 2-ft. lengths occupied by specials, and to pay an additional price for such specials. Specifications are often carelessly drawn and fail to state clearly how measurements are to be made, but a few specifications wherein measurements are clearly defined may serve to indicate the general practice. We quote:

> The length of sewer is to be measured horizontally, along the center line of the sewer, from the center of the uppermost flush-tank, or manhole, junction or outlet, as the case may be. . . . . Measurements of length thus include the manholes, flush-tanks and Y branches, in paying for the sewer; but each manhole, flush-tank, branch and other appurtenance is to be paid for, in addition to the price paid for the sewer, at the rate named in the proposal.

The foregoing is from a recent specification for the system of sanitary sewers for Yazoo City, Miss.; while the following is an excerpt from a recent specification for sewer work in Canandaigua, N. Y.:

> No deduction for the length of intermediate manholes or special pieces inserted into the line of sewer, will be made.

And, selecting another state we have from a recently drawn specification for a sewer system in Steelton, Pa., the following:

> Payments for all sewers shall be made by the foot, measurement being taken from center to center of manholes, including specials. House connections shall be measured from the center line of the main sewer along the pipe to the curb.

If it has been the practice of any engineer to specify a deduction for the length of specials in paying for the "sewer pipe furnished and laid," we have not seen an exemplification of such practice. In answering our correspondent's first query we have practically answered the last; for it is obvious that if any engineer intends departing from a well-accepted rule for measuring work he should take special pains to make clear in his specifications that such a departure is to be made. —Ed.]

Who Bears the Cost Where Unforeseen Difficulties Are Encountered in Work?

Sir: To settle an argument, will you kindly give me your opinion on the following question:

A certain bridge is let at a lump sum, on ordinary plans and specifications. The plans show the normal water level, the profile of the river bed, and, below this line, another line marked as hardpan. The intervening space between this hardpan and the river bed is marked as sand and gravel. Borings are given in the specifications at the abutments, showing a certain depth of sand and gravel, then hardpan. No borings are given at the piers. Depth of water, 12 to 15 ft.

In starting the cofferdam for one pier a bed of large stone is found on the river bed at the location of this pier. This stone completely covers the bed of the pier, as a pavement, and seems to occur in this one place only. It may be accounted for by the fact that a scow load of large stone is rumored to have upset in that vicinity several years ago. Below this bed of stone, also in the other piers, is sand and gravel, as per plan, with only an occasional boulder.

As the existence of this bed of stone was unknown at the time of letting, does it, or does it not, entitle the contractor to an "extra?"

Yours very truly,
Engineer and Contractor.

Oct. 4, 1903.

[The answer to this query depends almost entirely upon the existence or non-existence of a certain paragraph in the specifications. The paragraph referred to is one so often inserted for the purpose of throwing all the burden of uncertainty upon the contractor. The wording varies widely in different specifications, but ordinarily is somewhat as follows:

> It is further agreed that all loss or damage arising from any unforseen obstructions or difficulties encountered in the prosecution of the work shall be sustained by the contractor. The testpits and borings, and cross-sections based thereon are to be taken merely as guides for the contractor in bidding, and must not be construed to relieve

him from responsibility in determining for himself the nature of the materials to be excavated.

When such a paragraph forms part of a specification there can be little doubt that the contractor cannot recover for "extras" when materials of an unexpected nature are encountered, although not shown upon the plans. Where the difficulties that are encountered prove to be enormous, then it is an open question whether the contractor is not justified in stopping work and appealing to the courts, even under such a specification. But where the extra work is of no great amount, and especially where the contractor might have discovered the difficulties himself by moderate exertion or expense, as in the case under consideration, a paragraph similar to the one above given would doubtless prevent any recovery for "extras."

On the other hand, if there is no such paragraph, and if there is a cross-section showing the character of the excavation, there is no doubt that the contractor should receive compensation for any extra expense entailed by reason of encountering unexpected materials, and it is probable that the courts would award an amount sufficient to cover the extra expense.—Ed.]

On a Sliding Scale of Prices for Sewer Trenching.

Sir: The "Engineering Record" recently advocated calling for sewer bids on a sliding scale of prices, according to the depth. I do not see how the bids are to be compared in this system, nor what is to prevent a bidder naming a price for excavation that would be unreasonably high in event of a change in grade.

Duluth sewer contracts contain a section which seems fair, and leaves no doubt as to which bid is the lowest. It is as follows:

In case the grade line of the sewer is changed by the engineer, the price bid for excavation in foundation shall be increased 10% for each foot the grade line is lowered; and decreased 10% for each foot the grade line is raised.

Of course 10% in some cases is too much, and in some cases not enough, but this system is simple and in our soil works out reasonably close to justice.

I should be gratified to learn what methods are adopted by other cities. Very respectfully,

Edward K. Coe, Prin. Asst. City Engineer.

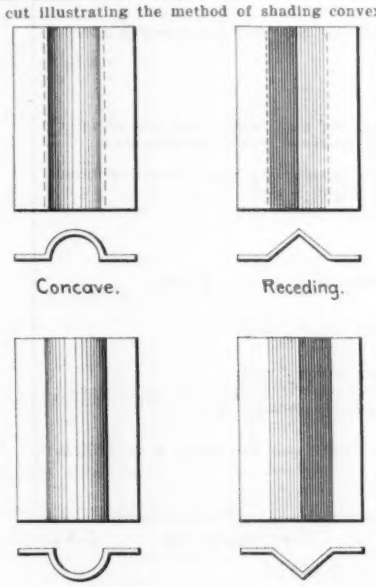
Duluth, Minn., Oct. 6, 1903.

[An examination of a large number of recent sewer specifications discloses the fact that very rarely is provision made for a change of price depending upon a change in depth of excavation; and, as a matter of fact, it is questionable whether there need be any sliding scale of prices ordinarily, provided the excavation and backfill are paid for by the cubic yard. In many cities it is the practice to pay for pipe sewer work by the linear foot, including excavation, and a great many engineers do not even classify the excavation, or in any way indicate what kind of material the contractor may expect to encounter. Character of material is of far greater importance ordinarily than the height to which it must be raised, and where cableways or trench machines are used the depth of trench makes very slight difference in the cost per cubic yard of excavation. Of course, there are soils in which large amounts of water are encountered below a certain level; then increased depth means increased pumping, and often increased cost of bracing. But the point that we desire especially to emphasize is that the cost per cubic yard of excavation in soil that does not change with depth is not materially affected by increased depth where machanical means are employed for handling the material.

As our correspondent truly says, an allowance of 10% increase in the unit price for each increased foot of depth makes it impossible to unbalance the bids, and it makes easy the determination as to what bidder is actually lowest; whereas to have a sliding scale of prices dependent upon depth introduces several serious complications. But who can safely say that the unit cost of trench excavation increases by any given percentage with each foot of increased depth? As we have indicated above, depth is not the only factor to be considered, since change in soil, and change in water outflow are not functions of the depth. It may be urged that with such a clause as the one quoted by our correspondent the contractor can enter no claim for extras in case the plans are changed; but even this is an argument of questionable force. If any change were made that resulted in greatly increased unit cost of excavation it is highly probable that the contractor would recover for it if he were to carry the matter to the courts, and he would recover in spite of any such clause. We believe that the simplest and most equitable method is to pay for the excavation and backfill by the cubic yard, and in case of any change in the plans that involves increased cost per cubic yard, pay the contractor for the actual increase in cost plus a stated percentage for his superintendence and profit. Generally a subsidiary contract can be made to cover any such change, so that it will not be necessary to work by force account, which is objectionable for more reasons than one.—Ed.]

Notes and Queries.

By an unfortunate error, the titles were transposed to the cut illustrating the method of shading convex and



Method of Shading Convex and Concave Surfaces.

concave surfaces, published on page 318 of our last issue. We therefore reprint the cut with the corrected titles herewith.

FIREPROOF CONSTRUCTION; DOES IT AFFORD ADDED FIRE PROTECTION?*

By Perez M. Stewart.†

No better proof can be asked of the fact that fireproof construction really does reduce the fire loss than is afforded by the favorable premium rates granted by Fire Insurance Underwriters on superior types of construction.

A careful consideration of the matter of fire protection should convince every owner that the introduction of safeguards against fire will bring a fair return in reduced rates on the increased outlay, besides fulfilling a moral obligation which he owes to his lessees, tenants, neighbors and himself.

Several theatres in New York have had their insurance rates materially reduced because of changes in their construction made at the instigation of the Department of Buildings.

Municipal regulations all over the country provide for almost every contingency which may occur affecting human life in theatres, or other places of public assemblage. Department stores, however, seem to be passed over entirely. Theatres and their management are provided for by a code as long as the moral law. In the case of department stores, however, probably three to five times as many people are allowed to congregate, to the square foot of building occupied, and yet no adequate provision for their safety is made.

Incombustible materials are not necessarily fireproof. It is important that this should be kept in mind. By fireproof materials is meant such as not only do not burn, but which, under the action of fire, remain intact and preserve their strength or the strength of those parts which they protect.

As an illustration of the distinction between incombustible materials and fireproof materials, we need only refer to the unprotected as against the protected or fireproof column. Cast-iron certainly will not burn, yet the effect of the heat of a fire is well shown in the bulging and collapsing of the unprotected columns of the Hackett-Carhart Building, at the corner of Broadway and 13th St., in New York city, last winter, causing nearly the entire roof and part of the floor below it to fall in. As against this may be mentioned the case of the McMahon Building in Chicago. This was a building occupied as a cracker bakery. One-half of the building was of the so-called slow-burning construction, consisting of columns, girders and floors of yellow pine material. At one end was erected a bakery, consisting of brick walls and steel beam and column construction, all protected by concrete.

A fire destroyed entirely the portion of the building of slow-burning construction. As exemplifying the splendid protection afforded to steel construction by a properly applied envelope of concrete, it may be stated that notwithstanding the intense fire existing in the slow-burning section, which abutted on the section occupied by the bakery, the bakery ovens, weighing in the neighborhood of one thousand tons, and supported upon the concrete-protected steel columns, remained in position at the end of the fire at their original height, extending from the third to the fourth stories.

The danger of the spread of fire in a building increases first, with the increase in area covered, and second, in greater degree with the increase in height.

The danger is met in the first instance by providing fire stops in the way of brick walls or fireproof partitions. Any openings that may be necessary in these partitions should be provided with fireproof doors and windows.

The spread of fire in a vertical direction is undoubtedly most effectively guarded against by making the floors continuous and unbroken, that is eliminating all openings in the floors and placing the necessary means of communication, such as stairways, elevators, pipes, shafts, belts, etc., in shafts entirely separated from the rest of the building by brick walls.

All casings, wainscoting, trim, etc., should be solidly backed up with some incombustible material; or in case it is impracticable to so back them up, good and sufficient fire stops should at least be provided at intervals. In non-fireproof buildings where wood floors or stud partitions are used, a judicious use of fire stops is very desirable. In the spaces formed by wood floor beams, the floor and ceiling act as a flue through which the fire spreads very rapidly; so do the spaces between the treads in the soffits of stairs. In the case of wooden stairways it is very desirable that fire stops of some incombustible material should be provided. Steam coal ashes or similar incombustible materials placed flush with the floor beams make not only on excellent fire stop by protecting the floors to a great extent, but serve the additional purpose of deafening or preventing the transmission of sound. In fireproof floors where wood flooring is used secured to wooden sleepers, it is very important that the space between the sleepers up to the underside of the flooring be filled in solidly with some incombustible material.

The elevator shaft is a very frequent means of spreading fire. The shaft walls should be absolutely fireproof, and constructed of incombustible materials. The requirements of the Department of Buildings of New York city are that the proposed construction shall practically remain intact after being exposed to a fire maintained for one hour at a temperature of 1,700° F., and then subjected to a stream of water at 30 lbs. pressure for 5 minutes. Any construction that is used should be self-supporting. Such iron work as is necessary for the construction of the shaft should be thoroughly protected by fireproof covering. No woodwork whatever may enter into the construction. The necessary openings must be provided with fireproof doors.

Tables of fire loss, covering a number of years, show that nearly one-third of the fire loss of the country is due to the exposure hazard. Fire is communicated from one building to another in almost every case through wall openings—through doors or windows, and to provide against this danger fire protectionists have devoted some of their best endeavors.

A substitute for fireproof shutters is found in the fireproof window glazed with wire glass, set in sash and window frame covered with metal. Wire glass is made either with an opaque or polished surface, and the wire reinforcing, embedded in the glass itself, although keeping the window intact against the attack of a fire of almost any intensity, may be broken readily by the fireman when it becomes necessary to enter the building or introduce a fire stream. Among the recent important fires showing the efficiency of wire glass windows in reducing the exposure hazard, may be cited the Armour Lard Refinery, Union Stock Yards, Chicago; the Case Plow Works, in Racine, Wis., and the Mitchell Wool Warehouse, in Philadelphia. In each of these instances the spread of fire to very valuable properties standing but a few yards distant was prevented through the resistance offered by wire glass windows in the walls of the adjoining building.

The walls of buildings, wherever practicable, should extend two or three feet above the roof level. This is absolutely essential in the case of parapet walls, or walls adjacent to other buildings, to prevent the creeping of fire along the roofs.

Roof coverings must always be of some fireproof materials, such as tin, iron, slate or tile, and where openings exist a filling of wire glass skylights. These materials best resist the passage of heat from falling embers, or flames lapping over the parapet walls.

*Extract from a paper read at the Annual Convention of the International Association of Fire Engineers.

†Late Superintendent Department of Buildings, Borough of Manhattan, New York City.

MECHANICAL DRAWING IN A MODERN DRAFTING-ROOM.*

By George H. Follows.†

Before I can hope to present this subject intelligently, it is necessary to come to an understanding as to what a mechanical drawing is, and also what we mean by the modern drafting-room.

According to the Century Dictionary, "mechanical drawing" is a drawing made with the aid of instruments, as compasses, scales, rulers, etc.; or the method or art of producing such a drawing. Now, although this would seem to be the generally accepted definition, to my mind it does not nearly fill the bill. I would have mechanical drawing looked upon and taught as a "language;" a mechanical drawing becomes then the "writing of a language." This as a broad or general definition will suffice for the present; we shall arrive at something more complete and comprehensive later on. The part that instruments play in the writing of this language is analogous to the part that the typewriter plays in the writing of English. In both cases a certain amount of skill is required to manipulate the instrument, but mere mechanical skill does not make a draftsman any more than it makes a stenographer. In both cases comprehensive brain knowledge of the subject (backed by common sense) is the essential.

By a modern drafting-room I mean the drafting-room of a manufacturing concern as distinguished from that of a concern that simply makes things. And it must be an up-to-date manufacturing concern, one that desires its product to be in every way good, is prepared to grow to any size, and is managed by men who have already realized that the work of the drafting-room, like that of the shop, must be done systematically.

There are shops even now where the drafting-room is looked upon more as an irritating source of expense than anything else—"To be done away with some day, when we get things going." That, of course, is not the way we look at it. The drafting-room is of as permanent use and value to the whole concern as the tool room is to the shop. And we must in the first place grant it this permanent place; it must be expected to stay and to grow with the business.

In what follows I try to show what a mechanical drawing should be in order that it may play the part it should play in the modern machine manufacturing concern.

I like to look upon drawings as "tools" so made as to be of as much and as permanent use as possible to the whole concern, and particularly to the shop. They should contain all information needed by the shop, and by all offices connected with the shop, as well as such information as is needed for reference in the drafting-room; but drawings should in no way *interfere* with the shop. They should clearly and unmistakably indicate required *results* but "how to get the results" should, when possible, be left to the shop, where by right it belongs.

I have seen drawings that have contained instructions like plane, bore, file, chip, turn, mill, etc. Such instructions are, as a rule, not only unnecessary but often lead to trouble. If, for example, the shop decides to grind instead of chip, or mill instead of plane, the drawing is immediately at fault; in other words wrong. There is a general principle that should always be kept in mind by the draftsman: Drawings should be made right to stay right." This principle is many-sided in its bearings; for instance, it must be remembered when naming the parts of a machine: If on the spur of the moment a material is included in the name of a piece, as "wooden ring," "fiber washer," and it is decided later (we will say a year later, after all catalogues, circulars, and printed matter in general have been issued using these names) that the ring is best made of fiber and the washer of brass, there have been introduced two very absurb errors; we have a "wooden ring" made of fiber and a "fiber washer" made of brass. And it will not be at all an easy matter to root out these mistakes.

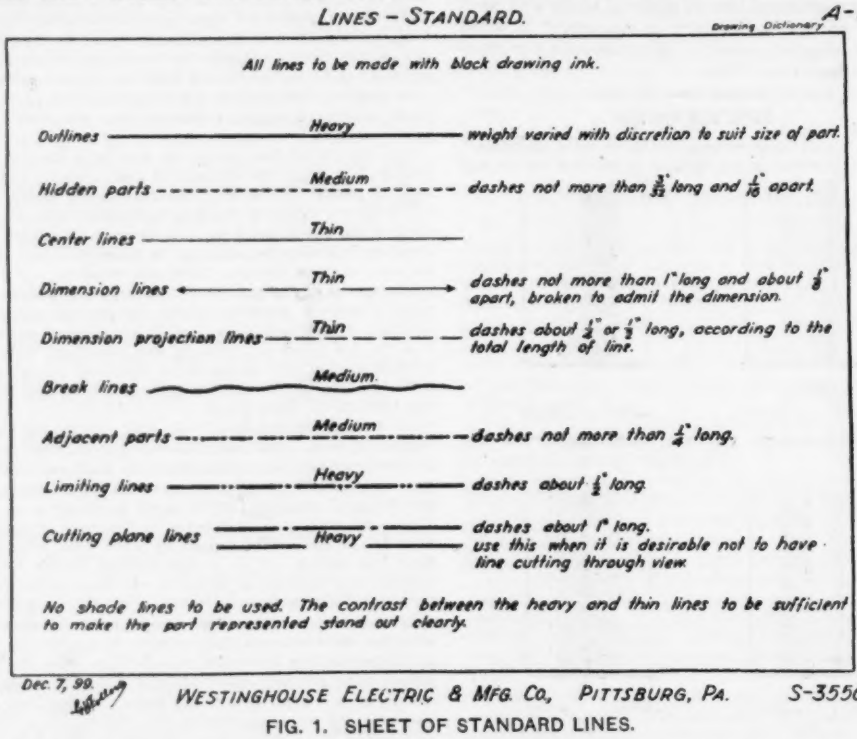

LINES – STANDARD.
A-1
Drawing Dictionary
All lines to be made with black drawing ink.
Outlines — Heavy — weight varied with discretion to suit size of part.
Hidden parts — Medium — dashes not more than 3/32" long and 1/16" apart.
Center lines — Thin
Dimension lines — Thin — dashes not more than 1" long and about 1/8" apart, broken to admit the dimension.
Dimension projection lines — Thin — dashes about 1/4" or 1/2" long, according to the total length of line.
Break lines — Medium.
Adjacent parts — Medium — dashes not more than 1/4" long.
Limiting lines — Heavy — dashes about 1/2" long.
Cutting plane lines — Heavy — dashes about 1" long. use this when it is desirable not to have line cutting through view.
No shade lines to be used. The contrast between the heavy and thin lines to be sufficient to make the part represented stand out clearly.
Dec. 7, 99.
WESTINGHOUSE ELECTRIC & MFG. CO, PITTSBURG, PA.
S-35567.

FIG. 1. SHEET OF STANDARD LINES.

Before going further I would like to say something (it will have to be very brief) about mechanical drawing as a language. This way of looking at it is not new, but it is made less of than it might be. When we think of a language, as of English, we have in mind an alphabet, words and sentences; and going further, to the written language as we find it in literature, we add, in the main, chapters and books. Now I would like to see it recognized that there is an analogy between English as a language and mechanical drawing as a language; the analogy can be made of real practical value to the student as well as to the teacher of the subject.

Under English we have: (1) An alphabet of letters, (2) words, (3) sentences, (4) chapters, (5) books.

Under mechanical drawing we have: (1) Analogous to the alphabet of letters an alphabet of lines, (2) analogous to words we have views, (3) analogous to sentences groups of views representing pieces, (4) analogous to chapters drawings (representing groups of pieces), (5) analogous to books complete sets of drawings representing complete machines.

In the matter of uniformity, makers of books have gone a long way ahead of makers of drawings. Take any two books and compare them; in general you will find on the back of each the name of the book, of the author, and of the publisher; inside you will come first to a title page, then a preface, then perhaps a frontispiece, and Chapter I. The page numbers are placed at the upper right and left-hand corners; each chapter is divided into paragraphs and the whole book into chapters. You will find this similarity even between books of to-day printed in this country compared with books of 50 years ago printed in England.

If now you compare drawings made by different men you are pretty sure to find that they are as unlike as two like things can be. From the alphabet of lines to the style of figures and letters, arrangement of views, position and style of title, and drawing number, there is an almost endless variety.

In any comparison between books and drawings, the books have the better of it, and the reason is not far to seek. The English language and the making of books has been studied as a language, while the making of mechanical drawings has been left to a large extent to the fancy or taste of the individual draftsman.

Not long ago I heard an engineer say, "Some people seem to find it just as difficult to convey a thought in English as some draftsmen do to convey an idea by means of a drawing." The reason is the same in both cases, insufficient knowledge of the language as a language.

Before an economical study can be made of a language, we must have some kind of standard dictionary. Nearly four years ago, when I first looked into the matter of a drawing system for the Westinghouse Electric & Mfg. Co., we began with the tracings; the reason for this was that it is prints from tracings that are used in the shop and business of the company, and we wanted to see results as soon as possible. The first thing determined was the alphabet of lines (Fig. 1). Then followed lettering and figures (Fig. 2), and sectioning (Fig. 3). Then came instructions regarding dimensions, dimensioning, finishes and finish marks; then the several mechanical features of a drawing, covering size of sheet, position and style of the title, drawing number, signatures, and several other features peculiar to Westinghouse drawings.

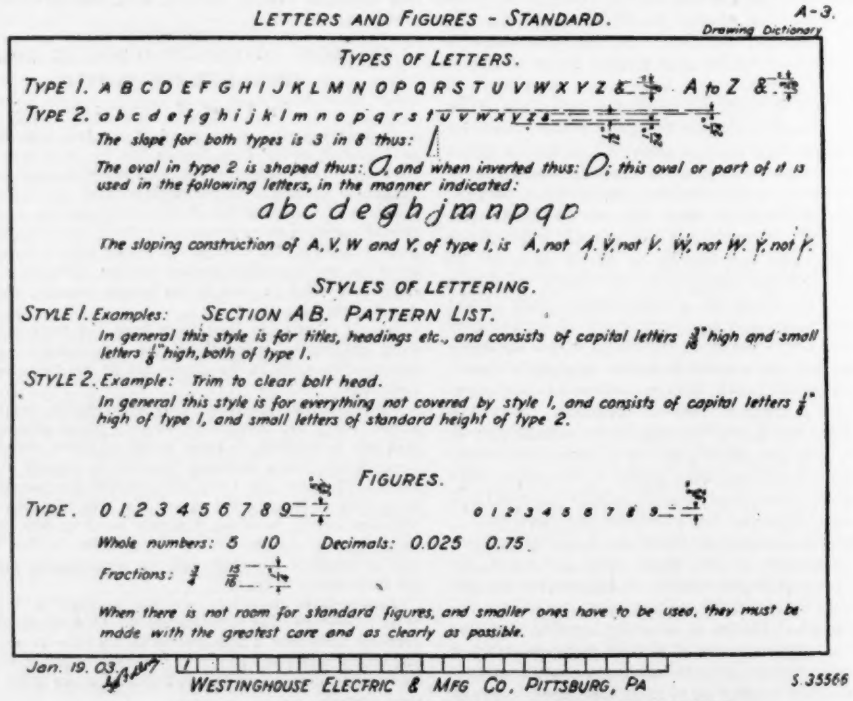

LETTERS AND FIGURES - STANDARD.
A-3.
Drawing Dictionary
TYPES OF LETTERS.
TYPE 1. A B C D E F G H I J K L M N O P Q R S T U V W X Y Z & — A to Z &
TYPE 2. a b c d e f g h i j k l m n o p q r s t u v w x y z &
The slope for both types is 3 in 8 thus:
The oval in type 2 is shaped thus: and when inverted thus: this oval or part of it is used in the following letters, in the manner indicated:
a b c d e g h j m n p q o
The sloping construction of A, V, W and Y, of type 1, is A, not A. V, not V. W, not W. Y, not Y.
STYLES OF LETTERING.
STYLE 1. Examples: SECTION AB. PATTERN LIST.
In general this style is for titles, headings etc., and consists of capital letters 3/16" high and small letters 1/8" high, both of type 1.
STYLE 2. Example: Trim to clear bolt head.
In general this style is for everything not covered by style 1, and consists of capital letters 1/8" high of type 1, and small letters of standard height of type 2.
FIGURES.
TYPE. 0 1 2 3 4 5 6 7 8 9 — 0 1 2 3 4 5 6 7 8 9
Whole numbers: 5 10 Decimals: 0.025 0.75
Fractions: 3/4 15/16 — 1/4
When there is not room for standard figures, and smaller ones have to be used, they must be made with the greatest care and as clearly as possible.
Jan. 19. 03
WESTINGHOUSE ELECTRIC & MFG CO, PITTSBURG, PA
S 35566

FIG. 2. SHEET OF STANDARD LETTERS AND FIGURES.

This dictionary is a 20-page book, and being the foundation of the language, every member of the drafting-room is provided with a copy. The immediate result of this dictionary was the cutting out of individual peculiarities in the appearance of tracings made by different men. The 50,000 tracings made since the dictionary was adopted

*Reprinted from the "Proceedings of the Engineers' Society of Western Pennsylvania."

†Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

are uniform Westinghouse tracings, and all look alike. In fact, a few days after a tracing has been made, if by any chance the tracer has neglected to put his name on in blue pencil (as is our custom) it is not at all uncommon for several men to claim it as their own work.

It is pretty generally admitted, I believe, by those of extended drafting-room experience, that the modern school or college course does not properly prepare a man for actual work in the modern drafting-room. Not long ago I read a letter from a young mechanical engineer in which he spoke of "mere mechanical drawing." He probably had reference to the mere making of lines—analogous to the mere thumping of the keys of the typewriter.

A draftsman cannot hope to play the part he should in the modern drafting-room until he has educated himself

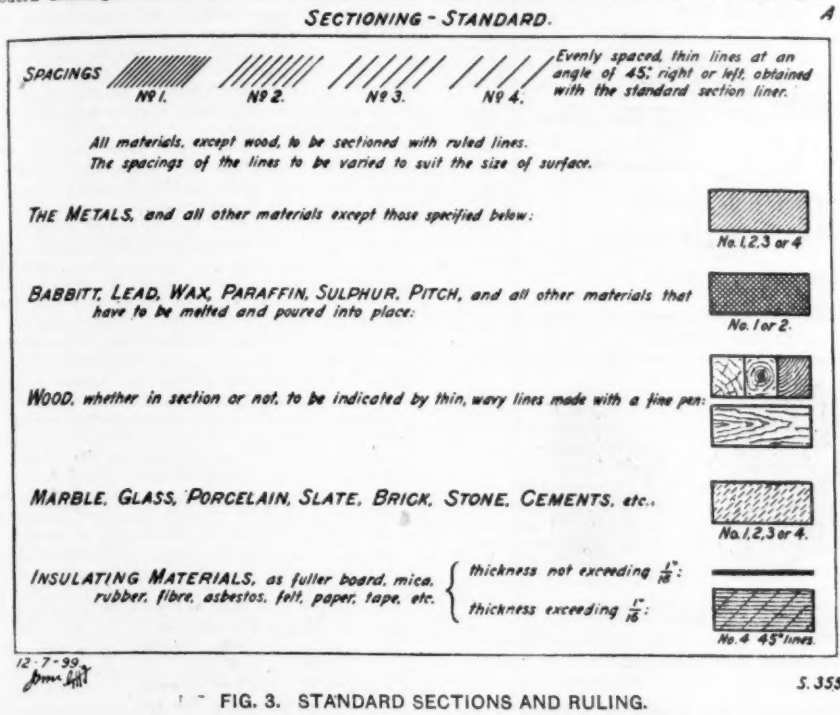

SECTIONING - STANDARD.
A 0
SPACINGS
No 1.
No 2.
No 3.
No 4.
Evenly spaced, thin lines at an angle of 45° right or left, obtained with the standard section liner.
All materials, except wood, to be sectioned with ruled lines.
The spacings of the lines to be varied to suit the size of surface.
THE METALS, and all other materials except those specified below:
No. 1, 2, 3 or 4
BABBITT, LEAD, WAX, PARAFFIN, SULPHUR, PITCH, and all other materials that have to be melted and poured into place:
No. 1 or 2.
WOOD, whether in section or not, to be indicated by thin, wavy lines made with a fine pen:
MARBLE, GLASS, PORCELAIN, SLATE, BRICK, STONE, CEMENTS, etc.:
No. 1, 2, 3 or 4.
INSULATING MATERIALS, as fuller board, mica, rubber, fibre, asbestos, felt, paper, tape, etc.
thickness not exceeding 1/16":
thickness exceeding 1/16":
No. 4 45° lines.
12-7-99
S. 35568

FIG. 3. STANDARD SECTIONS AND RULING.

up to his work, which is not merely the making of accurate drawings—although that is an important part of it—but the writing of a language for somebody else to read—and to read, too, without any verbal assistance from him. It must be remembered that the man in the shop is not a mind reader; I have heard it said that a draftsman *has* to be, but even that does not help the man in the shop. The language itself (and this may be taken as a fairly comprehensive definition) is one of lines, views, and group-signs, and abbreviations, notes and explanatory matter, all for the *positive* conveyance of *exact* information to the shop

A mechanical drawing should contain *all* necessary information, and nothing else; every statement, whether made by means of lines or words or combinations of lines and words, should absolutely be free from ambiguity and as clear and easy to understand as the knowledge and common sense of the draftsman can make it.

There are in the main two sides to the draftsman's knowledge and work: First, How to convey information; second, What information to convey. The college education could easily take care of the first, if only an international standard dictionary were accepted and followed. And in connection with machine construction and design much of the second could be taken care of too, especially that very important part of design that relates to fasteners—means of securing pieces together—as bolts, screws, rivets, pins, keys, nuts, washers, etc. How to specify and convey information about these and other mechanical details and parts that are common to many machines could be usefully taught at college, provided a recognized standard existed. In other words the college course might be made to prepare a man much more thoroughly than it does for actual work, only leaving his education to be completed in practice, instead of as very often happens now, both begun and completed.

The part of the draftsman's education that properly and necessarily belongs to the drafting-room relates to special manufacturing information. In this connection it must be borne in mind that the modern drafting-room should be a manufacturing concern, or factory, in itself. The distinction between a factory and a shop is generally taken to be that the work done in the factory is on a larger scale. A better distinction, I think, is that in the factory things are manufactured systematically and uniformly—not simply made; things can be manufactured in small quantities as well as in large. The modern drafting-room then may turn out either many or few drawings. It is modern in the sense of being up-to-date if the drawings speak one good language, instead of a number of dialects, are made systematically, and are uniform as to mechanical features.

The particular drafting-room in which I am interested is turning out drawings at the rate of 20,000 a year, and a constant effort is being made to get things down to a manufacturing basis—I mean as to the drawings themselves.

The drawing dictionary once established and the work of the tracers thus brought under control, we turned our attention to the designers, draftsmen and clerical force. This resulted in the formation of a separate department called the Standard Division, for keeping the drafting-room posted on Westinghouse practice, prepared forms for the transaction of business, the designing of standard parts of machines, the investigation of standard methods of figuring, and the up-to-date posting of draftsmen regarding stock sizes.

The first thing taken up by the department was the matter of nomenclature, which resulted in a book of element

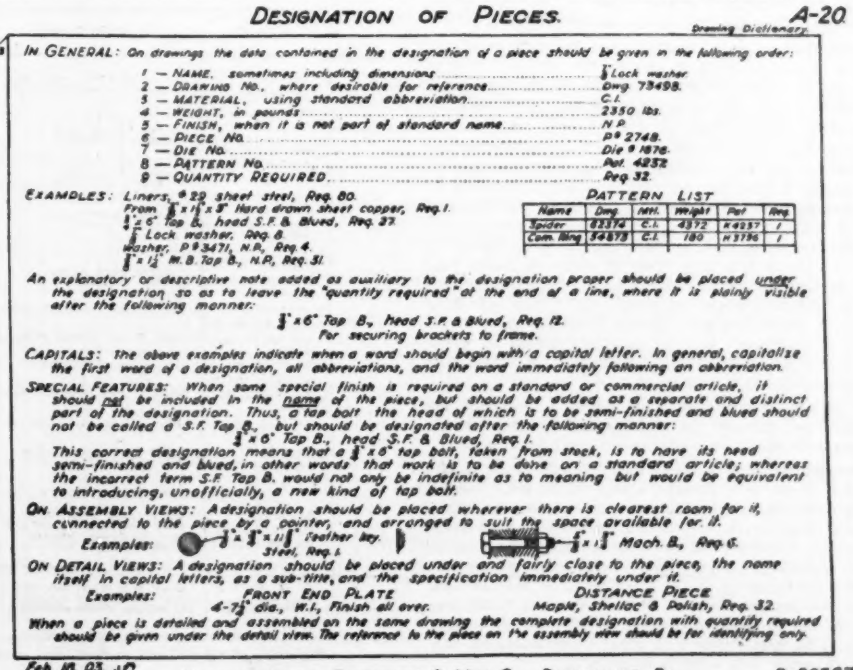

DESIGNATION OF PIECES.
A-20
Drawing Dictionary.
IN GENERAL: On drawings the data contained in the designation of a piece should be given in the following order:
1 — NAME, sometimes including dimensions ... 3/8 Lock washer.
2 — DRAWING No., where desirable for reference ... Dwg. 73498.
3 — MATERIAL, using standard abbreviation ... C.I.
4 — WEIGHT, in pounds ... 2350 lbs.
5 — FINISH, when it is not part of standard name ... N.P.
6 — PIECE No. ... P.P. 2748.
7 — DIE No. ... Die P 1876.
8 — PATTERN No. ... Pat. 4252
9 — QUANTITY REQUIRED ... Req. 32.
EXAMPLES: Liners, 0 22 sheet steel, Req. 80.
From 1/4 x 1 1/2 x 3" Hard drawn sheet copper, Req. 1.
1/2 x 6" Tap B., head S.F. & Blued, Req. 27.
3/8 Lock washer, Req. 8.
Washer, P.P. 3471, N.P., Req. 4.
3/4 x 1 1/2 M.B. Tap B., N.P., Req. 31.
PATTERN LIST
Name | Dwg. | Mtl. | Weight | Pat | Req.
Spider | 83374 | C.I. | 4372 | K 4237 | 1
Com. Ring | 54873 | C.I. | 180 | H 3796 | 1
An explanatory or descriptive note added as auxiliary to the designation proper should be placed under the designation so as to leave the "quantity required" at the end of a line, where it is plainly visible after the following manner:
3/4 x 6" Tap B., head S.F. & Blued, Req. 12.
For securing brackets to frame.
CAPITALS: The above examples indicate when a word should begin with a capital letter. In general, capitalize the first word of a designation, all abbreviations, and the word immediately following an abbreviation.
SPECIAL FEATURES: When some special finish is required on a standard or commercial article, it should not be included in the name of the piece, but should be added as a separate and distinct part of the designation. Thus, a tap bolt the head of which is to be semi-finished and blued should not be called a S.F. Tap B., but should be designated after the following manner:
3/4 x 6" Tap B., head S.F. & Blued, Req. 1.
This correct designation means that a 3/4 x 6" tap bolt, taken from stock, is to have its head semi-finished and blued, in other words that work is to be done on a standard article; whereas the incorrect term S.F. Tap B. would not only be indefinite as to meaning but would be equivalent to introducing, unofficially, a new kind of tap bolt.
ON ASSEMBLY VIEWS: A designation should be placed wherever there is clearest room for it, connected to the piece by a pointer, and arranged to suit the space available for it.
Examples:
3/4 x 3/4 x 1 1/2 Feather key. Steel, Req. 5.
3/4 x 1 1/2 Mach. B., Req. 6.
ON DETAIL VIEWS: A designation should be placed under and fairly close to the piece, the name itself in capital letters, as a sub-title, and the specification immediately under it.
Examples:
FRONT END PLATE
4-7/8" dia., W.I., Finish all over.
DISTANCE PIECE
Maple, Shellac & Polish, Req. 32.
When a piece is detailed and assembled on the same drawing the complete designation with quantity required should be given under the detail view. The reference to the piece on the assembly view should be for identifying only.
Feb. 18, 03.
WESTINGHOUSE ELECTRIC & MFG. CO., PITTSBURG, PA.
S-80397

FIG. 3-a. SAMPLE LEAF OF DRAWING DICTIONARY.

charts and an illustrated index. In general the purpose of the element charts is to insure throughout the business of the company uniformity of nomenclature on all drawings, specifications and correspondence. The chart reproduced in Fig. 4 is for the Direct-Current Engine Type generator. With this in his possession the draftsman at once knows the official name of every element and part of the machine; he knows what pieces should be detailed separately; the half-tone of the completed machine tells its own story and so does the sectional assembly drawing beside it. In talking or writing about or designing any one of these elements that go to make up the machine there is no room for misunderstanding as to the meaning of a term. For instance: The Element "Frame" in this machine includes frame castings, poles (punchings, side plates, bars, rivets), stud bolt and nuts, eye bolts and liners; and so with the other elements.

While settling these matters concerning the names of the principal parts of standard-type machines, we took up the naming of small pieces, as screws and other fasteners, and also much-used parts of machines. The result of this was the Illustrated Index, one page of which is reproduced in Fig. 5. Every draftsman has the complete index and has therefore no excuse of any error in designating any piece included in the index. Of course, these books and others that are referred to below grew gradually and are still growing, becoming more comprehensive every month.

In the modern drafting-room draftsmen have no time to hunt for dimensions of standard parts. As soon as possible then after a piece becomes standard for general use, every draftsman should be put in possession of its dimensions, so that whenever he wishes to use it he can go ahead promptly and draw it to scale without having to hunt up information.

Every draftsman in the Westinghouse drafting-room has a set of 51 sheets containing standard dimensions, and these are being added to every week. The page reproduced in Fig. 6 shows the style in which information of this kind is put up.

Another outcome of the Standard Division is the Engineers' Note Book. One page is shown in Fig. 7. If there is to be uniformity in design of any apparatus or piece where strength has to be figured, designers must use the same method of figuring, and this method should be thoroughly investigated before being accepted as standard.

So far we have dealt only with what may be called internal information. Quite as important to the drafting-room and to the concern itself, because of its influence on profit and loss, is information directly connected with the factory: I refer particularly to stock sizes of manufacturing material.

In modern drafting-rooms, whether large or small, draftsmen should be kept thoroughly posted as to the sizes of standard parts kept in stock in the shop store rooms. If this is not done, innumerable unnecessary sizes of these parts will gradually creep into use, which means money locked up in unnecessary stock, and just so much more scrap at the end of every year. This posting should cover stock patterns as well as finished parts and raw materials. It is the duty of a modern draftsman to make a choice from stock unless it is absolutely necessary to introduce a new piece. That is where some of the individuality of the draftsman is passing away. The draftsman needs all the ingenuity as designer and schemer that he ever did—he never needed more—but in the modern drafting-room his ability should be directed along lines that will result in work of the greatest value to the concern. In the Westinghouse drafting-room there is a large swing-leaf poster, see Fig. 8 (japanned sheet metal leaves hinged around a rotating vertical column) upon which

stock bulletins are secured by means of clips. This poster stands in a place of easy access and can be referred to by several men at the same time, and fills its purpose admirably, containing up-to-date information regarding sizes of materials that are kept in stock in the several shop storerooms of the company; also miscellaneous information that is made sufficiently available to draftsmen by being posted in this way.

Information regarding existing patterns, dies and tools, etc., is carried for the most part in card indexes.

In every drafting-room the Chief Draftsman finds it necessary from time to time to issue instructions; some to the drafting-room as a department, others to the divisions of the department. These instructions frequently emanate from the officers of the company, and affect standard practice. Whatever they may be, if they are instructions for permanent following they must be in writing, must be read by all concerned and not forgotten; in other words, these instructions must be carried out at all times.

In the Westinghouse drafting-room instructions of this kind are issued as circular letters; the complete book of them at the present time is a volume of about 400 pages of typewritten matter, the whole being duplicated six times for reference in different parts of the room.

It is perhaps needless to say that it is practically impossible for any man to remember so many instructions of so varied a character, and quite out of the question for a draftsman to wade through a volume of 400 pages to look up doubtful points of practice. The solution of this has been found in what we call the "Circular Letter Digest." This is a printed book of some 30 pages (and every draftsman has a copy of it), in which the instructions are classified according to the subject they bear upon and in which the substance of each letter has been "boiled down" or "digested" into the smallest number of words consistent with intelligibility, frequently a single line taking the place of a long letter.

One of the happy results of having information for draftsmen put together in concise and intelligent form is the ease with which it is possible to break in new men.

Reference has been made to the dividing of the drafting-room force into designers and draftsmen, tracers, checkers and clerks. In a large concern like the Westinghouse company, where there is a drafting-room force all told of about 350, these divisions are more distinct than in small concerns, but they always exist to some degree and all members of the force must be kept in line. The clerical part of the work must be done on forms prepared for the purpose, so that all records may be quickly made and correspondence with other departments be official in character and uniform in style.

The drafting-room (speaking now in general) has been grossly neglected in matters of form and methods of procedure. While the executive end of business has been fully equipped with printed forms for the transacting of every detail of its work, the drafting-room has been generally expected to make what it can of blank sheets of paper for drawings and a scratch-pad for correspondence. This is not as it should be and in the modern drafting-room it is a condition that is rapidly disappearing.

Even the checker, who is generally considered as sufficient unto himself and to have occult powers, should work systematically. The checking of drawings is of vital importance; mistakes are not mistakes until after they have eluded the checker's eye; the drawing like the machine is not ready for delivery until after it has been tested and inspected.

Fig. 8 shows our standard instructions to checkers.

In the Westinghouse drafting-room there is a large force of checkers and one inspector. The checkers are expected to follow the above advice. Draftsmen also are provided with the instructions and it is their business to make drawings so that they will check up in accordance.

Just how these instructions were arrived at may be of interest. One of the most systematic of our checkers was asked to give his ideas on the subject. A copy of his ideas was then handed to every checker in the room, with a request for other ideas; which after being sifted to the bottom resulted in the instructions as above.

The note, "You must know what is wanted before you go ahead with any checking," is an important reminder that speaks for itself. Every drawing after being checked is handed to the inspector, whose special duty it is to catch all deviations from standard in matters relating to the drawing considered as the writing of a language and under whose advice all records are made (generally on specially-ruled index cards) of such patterns and much used pieces as draftsmen may wish to refer to in connection with future designs.

In general, information to draftsmen belongs to one of two classes: It is either Standard or Special. Under Standard we have in the Westinghouse drafting-room the Drawing Dictionary, Element Charts, Illustrated Index, Circular Letter Digest, Example Drawings, and Abbreviations—six books bound in one cover, with index, and called the Standard Book. Every checker, draftsman and tracer has his standard book, the contents being suited in a general way to the work of the man. Under Special information are included records that have to be kept up-to-date. In general no attempt is made to post draftsmen individually on information of this kind, it being made as available as possible in other ways, as by card indexes and record books.

In conclusion I would like to point a moral: The mechanical draftsman will be a greater force and will the sooner gain that recognition he so frequently cries out for, when he ceases to permit his work to be the mere making of lines, and succeeds in elevating it to a higher plane—the writing of an exceedingly comprehensive and practically universal language. I have heard apparently intelligent men discuss for hours and throw fierce invectives in vain attempt to convince one another that such and such a way of filing drawings is better than any other; that the dull side of tracing cloth is better than the smooth side, or vice versa; that patterns should be numbered in this way, and not by any manner of means in that way; that original pencil drawings should always be carefully preserved, or officially destroyed as soon as the tracing is complete, that the bill of material should be in such a place on the drawing, or not in the drawing at all; that there should positively be a margin of one-half of an inch around every drawing; that the size of a drawing should be so much by so much, even according to the law of the Medes and Persians; and so on, ad libitum.

Surely all these things have been written about and talked about often enough to prove conclusively that it is waste of time to do either any more. It is as well to remember the old saying, "What is food for one may be poison for another."

Let each drafting-room, guided by a little common sense, settle these and similar things for itself, and then go ahead and write the language in such a way as to convey exact information clearly and concisely according to our definition; let the aim of those in charge of draftsmen be to keep them thoroughly and systematically posted; let every draftsman make it one of the essentials of his work to become familiar with shop practice and with everything that the firm he is with has already made or carried in stock or is accustomed to buy, and let his aim be to produce drawings that tell the shop clearly everything that the shop needs to know; let the draftsman do these things and he will get his reward.

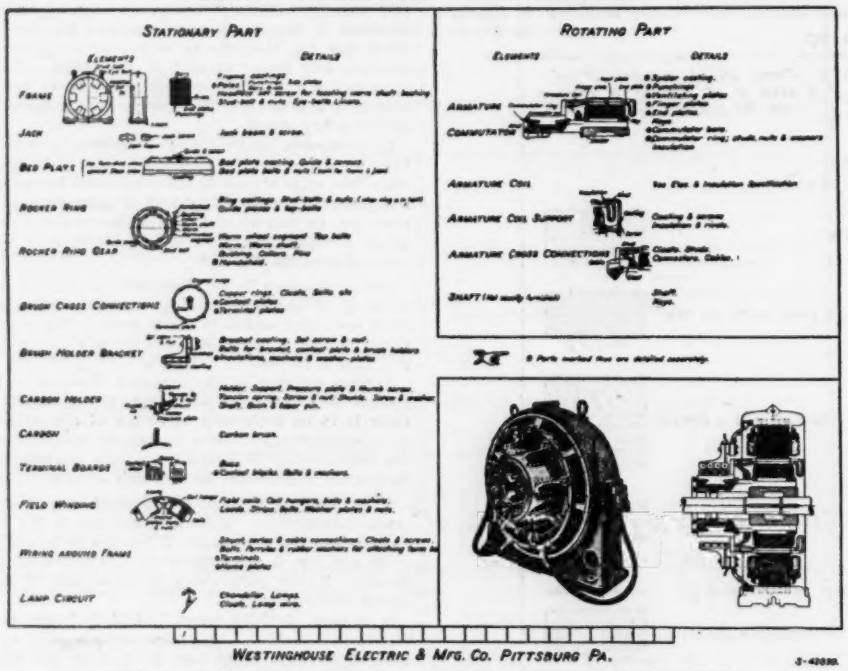


FIG. 4. ELEMENT CHART FOR DIRECT-CURRENT GENERATOR.

ILLUSTRATED INDEX. H 16

NAME	DESCRIPTION	STD. MTL.	ILLUSTRATION	GIVEN IN STD. DATA BOOK	S. Dwg. No.	EXAMPLE DESIGNATION
Set Sc. Set screw	Square head, cup point; case hardened; U.S. Standard threads.	W.I.	Length	Diameter. Length. Thread length. Mfrs. stock sizes	44638 44639	⅜" x 1½" Set Sc.
Hdless. Set Sc. Headless set screw	Less than ¼" diameter. Cup point, V threads.	W.I.	Length	Gauge. Thds. per inch. Length	44639 44640	#10-32 x ¾" Hdless Set Sc.
	¼" diameter and larger. Cup point. U.S. Standard threads.	W.I.	Length	Diameter. Length.		⅜" x 1½" Hdless Set Sc.
Fil. Hd. M. Sc. Fillister head machine screw.	V. threads. blued if iron, polished if brass.	Iron or Brass	Length	Gauge. Thds. per inch. Length. Thread length. Mfrs. stock sizes.	44635 44636 44638	#14-24 x ⅜" Fil. Hd. M. Sc.
Flat Hd. M. Sc. Flat head machine screw.	V. threads blued if iron, polished if brass.	Iron or Brass	Length	Gauge. Thds. per inch. Length. Thread length. Mfrs. stock sizes.	44636 44637 44638	#10-32 x ⅜" Flat Hd. B. M. Sc.
Flat Hd. Wd. Sc. Flat head wood screw	Bright if iron, polished if brass.	Iron or Brass	Length	Gauge. Length. Thread length. Mfrs. stock sizes.	44635 44636 44637 44638	#14-1½" Flat Hd. I. Wd. Sc.
Rd. Hd. Wd. Sc. Round head wood screw	Bright if iron, polished if brass.	Iron or Brass	Length	Gauge. Length. Thread length. Mfrs. stock sizes.	44635 44636 44637	#14-1½" Rd. Hd. B. Wd. Sc.
Lag Sc. Lag screw	Square head, gimlet point, body and head rough.	W.I.	Length	Diameter. Length. Thread length. Mfrs. stock sizes.	44639 44640	⅜" x 8" Lag Sc.
Mach. B. Machine bolt with one hexagon nut.	Square head, rough, body rough and slightly tapered up to head; U.S. Standard threads; Standard hexagon nut.	W.I.	Length	Diameter. Length. Thread length. Mfrs. stock sizes.	44635 44637	⅜" x 4½" Mach. B.
M. B. Mach. B. Milled body machine bolt with one hexagon nut.	Square head, rough; body and under head finished; U.S. Standard threads, standard hexagon nut.	W.I.	Length	Diameter. Length. Thread length.	44639 44640	⅜" x 3" M. B. Mach. B.

Aug. 8, 01. S 42383

FIG. 5. SAMPLE PAGE OF ILLUSTRATED INDEX OF NAMES OF SMALL PARTS.

ANNUAL CONVENTION OF THE LEAGUE OF AMERICAN MUNICIPALITIES.

The seventh annual convention of the League of American Municipalities was held at Baltimore, Md., Oct. 7 to 9, inclusive. Most of those in attendance were mayors or members of city councils, but there were a few engineers present.

THE ADVANTAGES OF MUNICIPAL CONSTRUCTION OVER THE CONTRACT SYSTEM.

The first paper was largely in the nature of an argument in favor of the direct municipal construction of sewers, paving and other public works. It was presented by Mr. James M. Head, Mayor of Nashville, Tenn. Prerequisites to success under this plan are honest and efficient officials, free from the domination of party bosses; good plant and a competent superintendent; and a competent engineering department, entirely distinct from the construction department.

The insuperable objection to the contract system, to Mr. Head's mind, is the fact that in most States the law requires that the contract be awarded to the lowest responsible bidder, and the law holds anyone responsible "who can give bond for the faithful performance of his contract." No matter how carefully drawn, bonds "are wholly inadequate to secure the prompt, faithful and satisfactory compliance with contracts." The speaker declared that:

> The contract system has done more to corrupt public officials and lower the standard of official integrity than any other one cause, save the granting of franchises to quasi-public corporations, which leads all other inducements to official crookedness.
>
> The only possible remedy for this condition of affairs under the contract system is to do away altogether with the rule requiring the acceptance of "the lowest bidder" and placing public officials upon their honor, and imposing upon them the responsibility of doing what is best for the city, and then holding them to a strict accountability for the results accomplished.

A spirited discussion followed this paper. Mr. Louis W. Anderson, City Engineer of Grand Rapids, Mich., and Mr. Henry Doll, of Columbus, O., each claimed that in their respective cities the contract system had given better results and caused less expense than the day labor plan.

Mr. Ignatius Sullivan, known as the "Labor Mayor" of Hartford, favored municipal construction, even at greater cost, "because the city can then be sure that the work will at least be done well, a thing impossible under the contract system." Prof. Frank Parsons, of Boston, said that it was unfair to compare the worst results under one system with the best under another. A representative example should be chosen for each side. He strongly favored municipal construction. Under private contract the motive is private gain: under direct municipal construction the motive is public service, resulting in better work for the city and better pay for the laborer. Mr. Samuel Jones, Mayor of Toledo, O., declared that to say a corporation will do better work than a city is to say that a part of the city is better than the whole. The true solution of all such problems is to have civic patriotism rise above party issues.

HOW CLEVELAND IS CHECKING WATER WASTE.

Mr. E. W. Bemis, Superintendent of the water-works at Cleveland, O., read a paper in which he outlined the methods followed in the rapid introduction of meters in that city. Some of the facts and figures in this paper were presented in our report of the convention of the Central States Water-Works Associations, in our issue of Sept. 24, 1903. Some two years ago the city set out to meter every service in the city, as rapidly as the department could install the meters and pay the cost of both meters and setting from current revenue. As it was desired to make meters popular, the city did not begin placing the meters where waste was at its worst. Instead, centers where average conditions prevailed were chosen and clean sweeps were made in every direction from these centers. Various minimum meter rates, or annual charges, were established, all below the flat or schedule rate for the same number of fixtures. This plan enabled the careful consumer to reduce his water bill, but put no premium on cutting the actual use of water below an ample allowance for all legitimate use. These two features, the possibility of saving money, and the removable of reasonable sanitary objections to meters, combined with the fact that some 90% of the metered consumers are actually getting water for less cost than formerly, and that a meter costs a consumer nothing, are making meters popular. Many requests are received for meters outside the districts where they are being regularly set, and a special gang is kept at work to meet this demand.

The change from a flat to a meter rate is not made until a consumer has been notified that he is using or wasting an unreasonable amount of water, and has had time to ascertain the cause and apply a remedy. The total revenue from metered water is an average of 6.24 cts. per 1,000 gallons. There is only one rate for citizens, but some outside municipalities buy water from Cleveland at 10 cts. per 1,000 gallons. The lowest minimum meter rate is $2.50 a year.

Referring to the so-called "free water" plan advocated by the late Mayor Pingree, Mr. Bemis said, in effect, that the nearest possible approach to free water would be to have every service metered and charge for all water used above a fixed quantity. Otherwise, free water would ruin the water department. The European method of house-to-house inspection would be more objectionable to people here than to Europeans. It is better to appeal to the pocket-book than to the policeman's club.

With the exception of Mayor Jones, the meter plan was endorsed by all who took part in the discussion. Mayor Jones thought that the paper illustrated the prevalent distrust of the people, and that the meter is really only a modified policeman's club.

GARBAGE AND SEWAGE DISPOSAL.

In the comparatively brief space allowed for a single paper, Mr. Rudolph Hering, M. Am. Soc. C. E., of New York, clearly outlined the principles and practice of both garbage and sewage

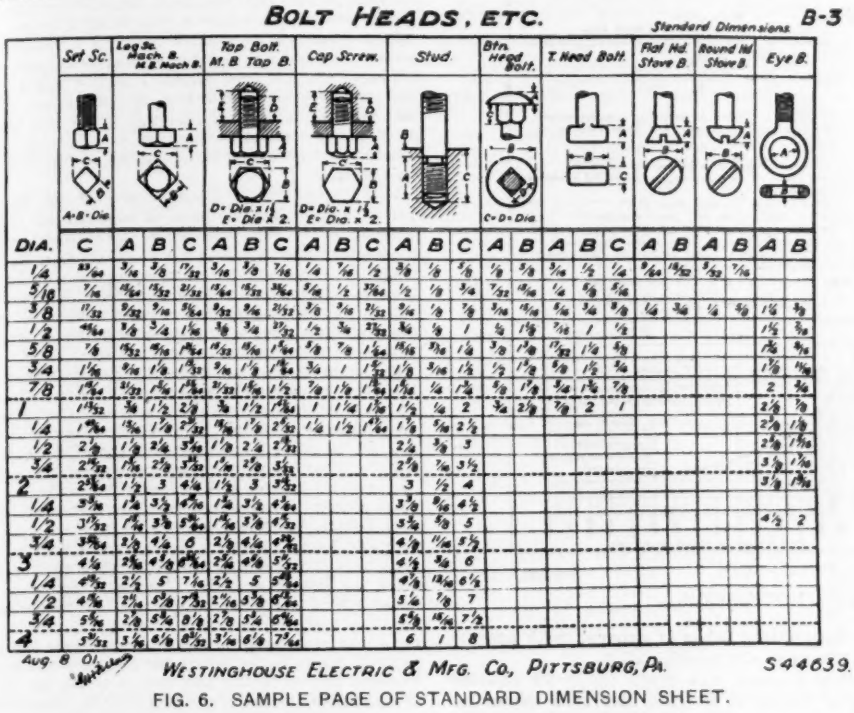


FIG. 6. SAMPLE PAGE OF STANDARD DIMENSION SHEET.

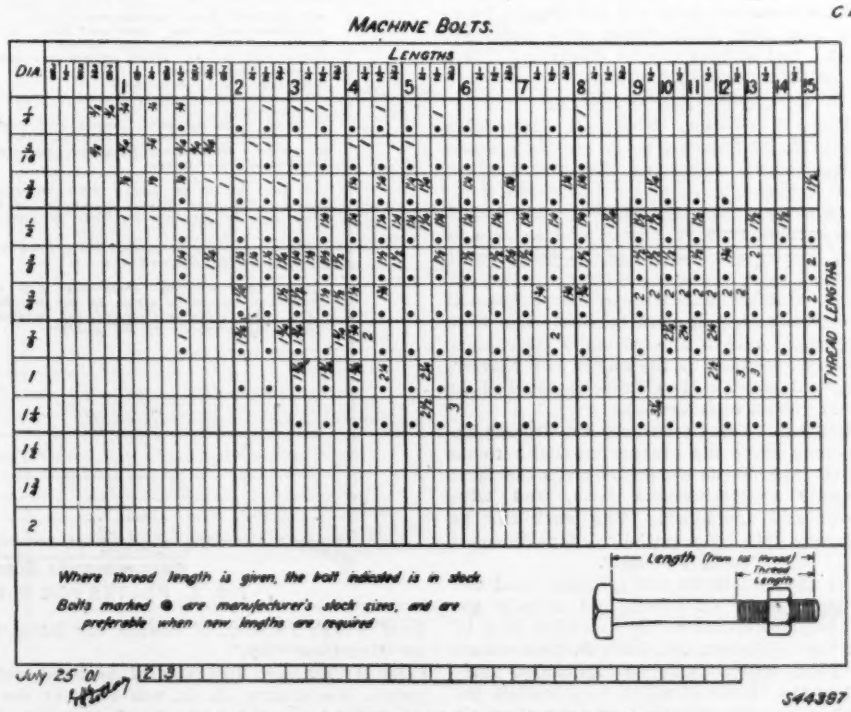

MACHINE BOLTS.
C 14
LENGTHS
DIA
THREAD LENGTHS
Where thread length is given, the bolt indicated is in stock.
Bolts marked ● are manufacturer's stock sizes, and are preferable when new lengths are required
Length (from 1st thread)
Thread Length
July 25 '01
S44397

FIG. 6-a. SAMPLE PAGE OF STANDARD DIMENSION SHEET.

disposal. European garbage furnaces are generally more satisfactory than those thus far developed by Americans. The unit of measurement for the proper dilution of sewage is the number of cubic feet of water flowing in a stream per 1,000 people contributing dilution thereto. The usual permissible range is 2½ to 7 cu. ft. per sec. of stream flow to 1,000 persons. Of the various methods of sewage treatment, intermittent filtration has not yet been equalled for effectiveness. One acre of sand filter beds, under average conditions, is sufficient for the sewage of 1,000 to 1,500 people. If the sewage has been previously treated in septic tanks with a capacity equal to one-half to one day's flow of sewage, the rate of intermittent filtration may be increased to perhaps ten times the ordinary rate. Contact beds can treat from 500,000 to 1,000,000 gallons of septic tank sewage per day. While the final effluent from contact beds will not usually be so pure as that from intermittent filter beds, yet the contact bed effluent can be discharged into a stream without danger of offense.

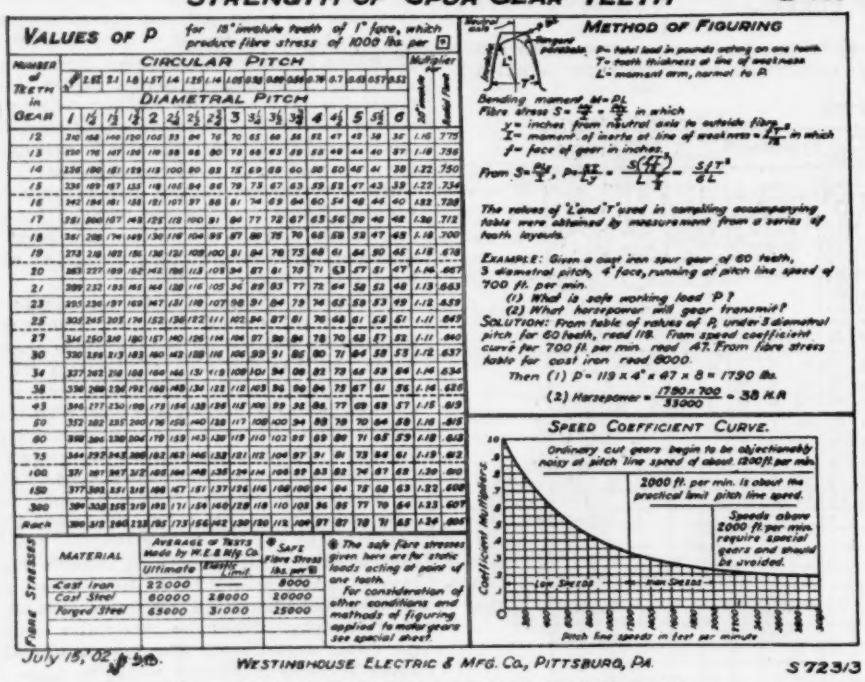

STRENGTH OF SPUR GEAR TEETH
B 40.
VALUES OF P
for 14½° involute teeth of 1" face, which produce fibre stress of 1000 lbs per
CIRCULAR PITCH
DIAMETRAL PITCH
Multiplier
METHOD OF FIGURING
Bending moment M=Pl.
Fibre stress S=
From
The values of 'L' and 'Y' used in compiling accompanying table were obtained by measurement from a series of tooth layouts.
EXAMPLE: Given a cast iron spur gear of 60 teeth, 3 diametral pitch, 4" face, running at pitch line speed of 700 ft. per min.
(1) What is safe working load P?
(2) What horsepower will gear transmit?
SOLUTION: From table of values of P, under 3 diametral pitch for 60 teeth, read 119. From speed coefficient curve for 700 ft. per min. read .47. From fibre stress table for cast iron read 8000.
Then (1) P = 119 x 4" x .47 x 8 = 1790 lbs.
(2) Horsepower =
SPEED COEFFICIENT CURVE.
Ordinary cut gears begin to be objectionably noisy at pitch line speed of about 1200 ft per min.
2000 ft. per min. is about the practical limit pitch line speed.
Speeds above 2000 ft. per min. require special gears and should be avoided.
Coefficient Multiplier
Pitch line speeds in feet per minute
FIBRE STRESSES
MATERIAL
Average of Tests made by W.E. & M. Mfg. Co.
Ultimate
Elastic Limit
Safe Fibre Stress lbs. per
Cast Iron 22000 — 8000
Cast Steel 60000 28000 20000
Forged Steel 65000 31000 25000
The safe fibre stresses given here are for static loads acting at point of one tooth.
For consideration of other conditions and methods of figuring applied to make gears see special sheet.
July 15, '02
WESTINGHOUSE ELECTRIC & MFG. Co., PITTSBURG, PA.
S 723/3

FIG. 7. SAMPLE PAGE OF ENGINEER'S NOTE-BOOK.

MUNICIPAL STATISTICS.

Mr. Hugo S. Grosser, Municipal Statistician and Librarian of Chicago, stated at the opening of his paper on Municipal Statistics that it would have no statistics in it, and he kept his word. He made a good plea for municipal statistical bureaus, so numerous in Europe and so rare in America. Boston was the pioneer in this respect in America, establishing a bureau five or six years ago. Chicago began systematic statistical work in 1901, and Baltimore in 1902. The New York statistical bureau, created under the charter of 1897, was abolished by the recent new charter. (A statistical division has been established in the finance department.—Ed.).

That city will be best governed, Mr. Grosser declared, which gives the greatest publicity to its operations. The people should be given the facts in an easily comprehensible form, and with promptness and frequency. The work can be properly done only by a statistical department.

OTHER PAPERS.

Some of the papers on the program need not be mentioned here. Of others, not already abstracted, brief reference or bare mention may be made of the following: Mr. John F. Hemenway, of New York, read a paper on "Municipal Telephones," in the course of which he described the municipal telephone service in Stockholm, and the municipal and State service elsewhere in Europe. He also made some statements regarding the independent companies in America and the extent to which they had cut under the rates of the Bell companies or compelled the latter to reduce their rates. If the independent companies could do business cheaper than the Bell and make a profit, why could not municipalities, with no desire for a profit, give service at lower rates than either?

A paper on "Organized Labor and the Municipality," by Mr. Ignatius Sullivan, Mayor of Hartford, proved to be wholly on the growth and claims of organized labor in general, with scarcely a reference to the municipality.

Thursday evening was given up to an address by Mayor Jones, of Toledo, and to a paper by Prof. Frank Parsons, of Boston, the latter being on "The Ideal City."

Mr. A. W. Dow, Inspector of Asphalts and Cements, Washington, D. C., was down on the program for a paper on "Paving." He was unable to be present, but forwarded his paper by mail. "The Operation of a Municipal Asphalt Plant" was assigned to Mr. John Arbuthnot, Mayor of Winnipeg, Manitoba. The operations of such a plant at Winnipeg for the years 1899 and 1900 were set forth in some detail in Engineering News of April 11, 1901.

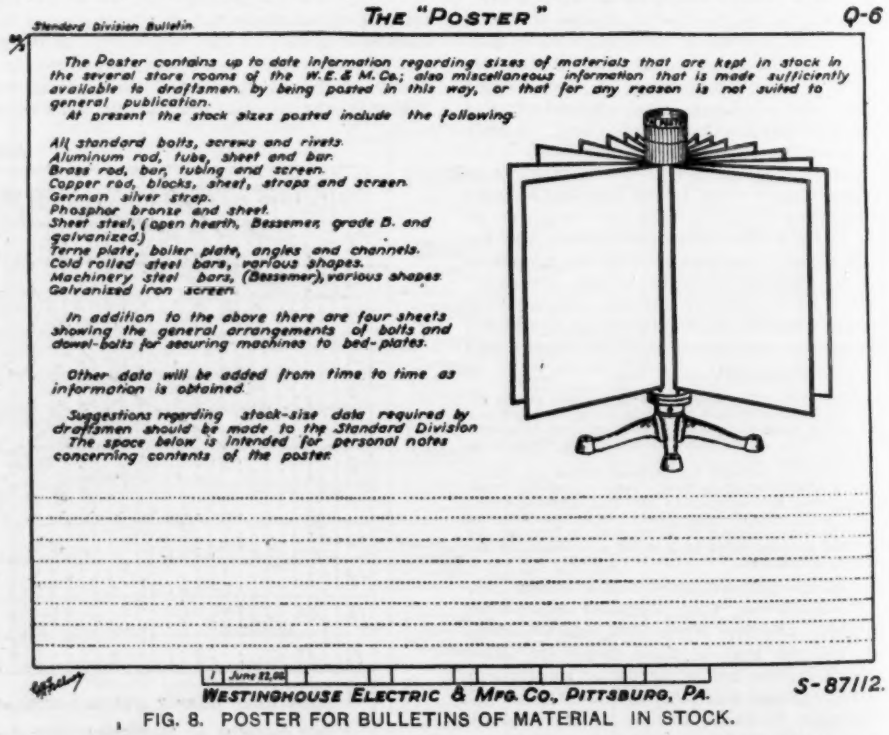

Standard Division Bulletin
THE "POSTER"
Q-6
The Poster contains up to date information regarding sizes of materials that are kept in stock in the several store rooms of the W.E. & M. Co.; also miscellaneous information that is made sufficiently available to draftsmen by being posted in this way, or that for any reason is not suited to general publication.
At present the stock sizes posted include the following:
All standard bolts, screws and rivets.
Aluminum rod, tube, sheet and bar.
Brass rod, bar, tubing and screen.
Copper rod, blocks, sheet, straps and screen.
German silver strap.
Phosphor bronze and sheet.
Sheet steel, (open hearth, Bessemer, grade B. and galvanized.)
Terne plate, boiler plate, angles and channels.
Cold rolled steel bars, various shapes.
Machinery steel bars, (Bessemer), various shapes.
Galvanized iron screen.
In addition to the above there are four sheets showing the general arrangements of bolts and dowel-bolts for securing machines to bed-plates.
Other data will be added from time to time as information is obtained.
Suggestions regarding stock-size data required by draftsmen should be made to the Standard Division.
The space below is intended for personal notes concerning contents of the poster.
June 22, 02
WESTINGHOUSE ELECTRIC & MFG. CO., PITTSBURG, PA.
S-87112.

FIG. 8. POSTER FOR BULLETINS OF MATERIAL IN STOCK.

THE EDUCATION OF ENGINEERS.*

By Wm. Kent, M. Am. Soc. M. E.†

What should be the course of a student in the university? If we had an ideal system of education and if the student had plenty of time to devote to his university training we might say that he should spend only three years in the liberal arts college, getting the windows of his mind opened, getting his brain power developed, so that he may know how to study and acquiring a broad liberal culture. He should graduate from this college at 21 years of age and then begin his three or four years' course in a special college leading to his becoming an artist, a teacher, a minister, a doctor, a business man, a government officer in the civil service, an architect, or an engineer. In the ideal system a man should not enter one of these colleges, until he is of sufficient age, until he has acquired correct methods and habits of study, and until his tastes and inclinations have been so far developed that he knows for what line of life work he is best adapted.

But our systems of education are not yet ideal, and partly on account of the haste of American life, partly on account of the poor preparation of the students in the preparatory schools (which are as yet far from ideal) and partly on account of the necessity of many students beginning to earn their own living in their early years, our special schools or technical colleges are taking in students who are imperfectly trained for beginning the severe courses of these colleges.

If I were to plan a course of preparatory instruction leading to a student's entering Smith College at the age of 19 and graduating at 23 with the degree of Civil, Electrical or Mechanical Engineer, I would give him as broad a training as possible in the preparatory school, qualifying him to enter either the philosophical or the scientific course of the Liberal Arts College of the University at 17 years of age. I would then send him, not to the Liberal Arts College, but into a machine shop, where for a year he would have to work ten hours a day. Here he would get a taste of the kind of experience which every engineer must get, sooner or later. He would get there some knowledge of the world of industry, of the methods of handling men, of the value of time. He would learn there that engineering is not only the science and art of utilizing the forces of nature for the benefit of man, as Tredgold defined it, but also that it is the art of overcoming the resistances of nature—including human nature. He would learn something of some of the kinds of human nature with which he will have to deal in later life. He would get physical and mental strength. Above all he would "find himself," as Kipling expresses it, and learn whether or not he had made a mistake in deciding to be-

*Extract from an address delivered before the entering class of the L. C. Smith College of Applied Science, Syracuse University, Oct. 2, 1903.

†Professor of Mechanical Engineering and Dean of the Smith College of Applied Science, Syracuse University, Syracuse, N. Y.

come an engineer. If all candidates for entrance into Smith College were compelled to take this preliminary year in the shop, perhaps 10 or 20% of them would discover before the year ended that they were not adapted to become engineers, a fact which without the shop training they might not discover until after they had graduated from the college and entered practical life. This shop training for the 80 or 90% who find by it that they have the natural capacity to become engineers, would be of great value to them in their subsequent college course. It has been the general experience of teachers of engineering that those boys who have had some experience in a shop make the best engineering students.

After the year in the machine shop the student should enter the college of Liberal Arts for one year, and here he should first correct the defects of his training in English in the preparatory school by learning how to spell and how to write in a passable handwriting a good English composition without glaring errors of grammar and rhetoric. Here also he should study physics, chemistry, mathematics, and the German language. Then he would be ready to enter Smith College.

There is a broad distinction between the student who takes the four years' course in the Liberal Arts college for any purpose whatever and the one who without that course takes the four years' course in Smith College.

The former student enters the four years' course in liberal arts with the intention of taking a course of study that will give him a broad general culture and fit him at the end of four years not to begin to earn his own living at say 22 or 23 years of age, but to begin three years more of study which will lead to his becoming a minister, a doctor, a lawyer, an artist, a teacher, or a man of business. In the Liberal Arts college he obtains no special knowledge which fits him to enter at once on any business or profession. He may enter with "little Latin and less Greek," perhaps no French or German, a smattering of mathematics, a knowledge of some English literature, but not such a command of the language as will enable him to write a presentable essay. In his course through the college, with our modern fashion of electives, he may dawdle away a large part of his time or spend it on subjects which will be of little benefit to him. He has plenty of time for athletics, and he may obtain a good general culture, a good physique, good social qualities, and be an all around good fellow, but it will take some years of further study or practical training before he is fitted to earn a living, which he may be able to do when he is 26 or 27 years of age.

The case of the average student of a college of engineering like Smith College is entirely different. His entrance requirements are in some respects higher. He must be better equipped in mathematics than the student who enters the Liberal Arts college. He must know something of either German or French and of physical science.

The object of the four years' course in Smith College is not merely to give him as broad a general culture as the time will admit, but also to develop his brain in a certain direction—that of solving difficult mathematical problems, and also, and chiefly to give him that special knowledge of engineering theory and practice which will enable him to enter at once, after graduation, upon the practice of his profession, and to earn money—say $50 per month at the start. The engineering college thus really attempts to crowd into four years the education which in other professions requires seven years. Of course, it can only be done, first by leaving out some of the culture studies which are preliminary to the other professional courses; second, by cutting down some of the time which the student in liberal arts gives to athletics and to society; third, by the most intense study and work during longer hours than those of the academic course.

CHECKING DRAWINGS.* Q-5

The following is intended as a guide when checking drawings. Each numbered feature should be taken up separately for any drawing or set of drawings (generally in the order given), and as each item is taken up it should be done thoroughly and as far as possible completed before passing on to the next. Every dimension, etc., should be ticked off with blue pencil as it is checked, and each feature checked off on Form S 78534 as a record both of what has been done and what remains to be done.

1 – *See that the drawing is made in accordance with the Westinghouse standard drawing system, and with the nearest related element chart. This part of the checking should cover the general contents of the drawing information for Specification Department, names of pieces and title of drawing.*

2 – *Check all dimensions by scaling, and, where advisable, by calculation also.*

3 – *See that each piece is correctly drawn, independent of dimensions; and that all necessary views are shown, but none that are not necessary.*

4 – *See that dimensions for the shop are given as required by the shop; that is, that the shop is not left to do any adding or subtracting in order to get a needed dimension. Give due attention also to dimensions that are specially for the Specification Dept. or for future reference in the M. E. Dept.*

5 – *Go over each piece and see that finishes of every kind are properly indicated or specified.*

6 – *See that every specification of material is correct, and that all required specifications are given.*

7 – *Check the pattern list with the patterns shown on the drawing, and with the pattern book in Standard Division, and also with similar patterns as tabulated in card indexes, etc., to make sure that no new patterns are ordered when old patterns already exist. Check Piece #s and Die #s.*

8 – *Compare with previous drawings of similar apparatus.*

9 – *Look out for interferences; this means check each detail with the pieces or parts with which it is to be assembled, and see that proper clearances have been allowed.*

10 – *When checking for clearances in connection with mechanical movements, carefully lay out the movement, to scale, figure the principal angles of motion, and see that proper clearances are maintained in all positions.*

11 – *See that all the small details, as screws, bolts, keys, pins, rivets, wires and cables, insulations, etc., are according to our standard, and that where possible stock sizes are chosen.*

12 – *In a general way review the drawing in its entirety in connection with any points that have suggested themselves during the above checking; and bear in mind all the information given in the following standard data books: Drawing Dictionary; Standard Dimensions; Stock Sizes; Example Drawings; Name Plates and Name Plate Charts; Element Charts; Finish Charts; Abbreviations; Illustrated Index; Hand Wheels; Flexible and Flange Couplings; Pulleys; Process Book, and all information available in the Standard Division.*

13 – *Check every feature of the title and record strip.*

14 – *Attend to all entries and correspondence in any way connected with the drawing.*

15 – *See that all lines and figures are heavy enough to make good Brownies.*

* *You must know what is wanted before you go ahead with any checking.*

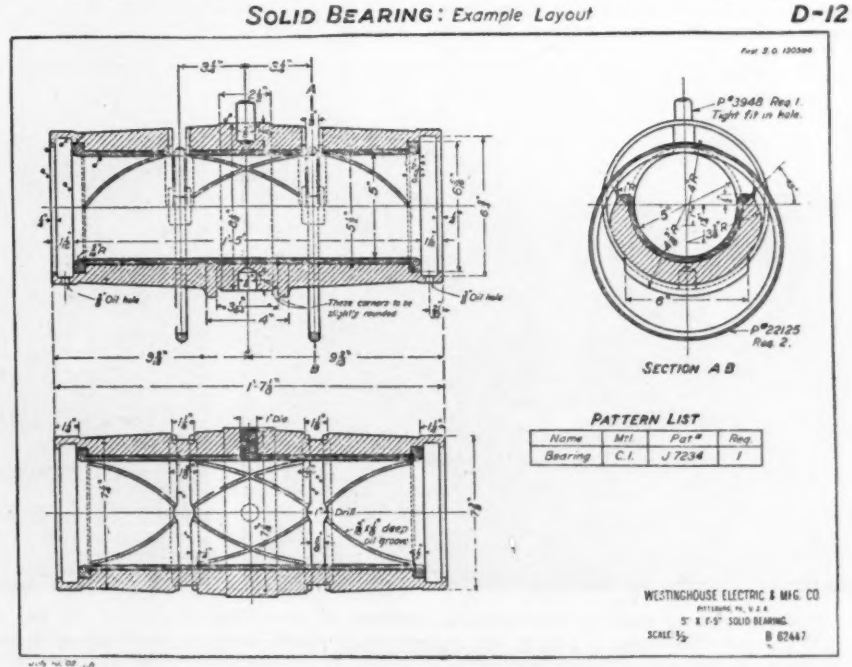
Jan. 5. 1905. WESTINGHOUSE ELECTRIC & MFG. CO., PITTSBURG, PA. S 78531

FIG. 9. STANDARD INSTRUCTIONS TO CHECKERS.

In this attempt, however, the engineering colleges of this country during the last thirty years have been eminently successful. They have turned out some thousands of young men, a large part of whom are now captains of industry, leaders of great enterprises, successful men in every sense of the word, men of broad culture and refinement, leaders of thought, in science, in business, and even in politics.

The essential conditions of success for such men is that they put away childish things early in their freshman year, and buckle down to four years of intense, hard work. Many of them work in shops during their vacations, and therein gain experience which helps them in their studies. A few of them—a very few—become famous in athletic contests, but they are exceptional men who come to the college endowed with active brains and sound bodies; and the average man in the engineering school, if he would keep up with his class in professional study can find no time for any more athletics than the necessary amount to keep him in good health. So also the engineering student can have but little time for social pleasures. The average student in order to graduate must make up his mind to spend at least 9 or 10 hours a day in study, in work in the shops, drawing rooms and laboratories and in the lecture and recitation rooms.

SOLID BEARING: *Example Layout* D-12


P°3948 Req 1. Tight fit in hole.
P°22125 Req. 2.
SECTION A B
PATTERN LIST
Name | Mtl | Pat° | Req.
Bearing | C.I. | J 7234 | 1
Oil hole
These corners to be slightly rounded
Drill ⅛" deep oil groove
WESTINGHOUSE ELECTRIC & MFG. CO
5" X 6-5" SOLID BEARING.
SCALE ½
B 62447

WESTINGHOUSE ELECTRIC & MFG. CO. PITTSBURG PA. S-71795

FIG. 10. EXAMPLE ILLUSTRATING STANDARD PLACING OF DRAWING ON SHEET.

A NEW SYSTEM OF CONCRETE RE-ENFORCEMENT, DESIGNED TO RESIST VERTICAL SHEAR.

By Julius Kahn, Assoc. M. Am. Soc. C. E.*

So much actual work is being done at the present time with re-enforced concrete, and in general, the subject is receiving such attention from the engineering world at large, that the method of re-enforcement described in this article, it is believed, will be of interest.

It is fairly well recognized among engineers that vertical re-enforcement for concrete beams is quite as essential as the horizontal re-enforcement, and in many cases the horizontal rods are surrounded by U-shaped stirrups of band iron or twisted rods. It was noticed at first by European engineers that a concrete beam, when tested to destruction under uniform loading, invariably failed by shear at the ends, the lines of rupture corresponding closely to the lines of principal compressive stress for such a beam. The attention of American engineers was called very strongly to this method of failure by Captain John Stephen Sewell, and illustrated with photographs in the Engineering News of Jan. 29, 1903.

The writer has also made a number of tests on beams re-enforced with plain and deformed rods on the bottom, and without one exception, all such beams when tested to destruction under uniform loading, failed by vertical or longitudinal shear, in exactly the same manner as originally pointed out by Captain Sewell.

The matter of vertical re-enforcement is certainly of more importance than some American engineers have been willing to grant to it. To the writer it seems most natural that rupture should occur in this manner; in fact, he can hardly conceive of its occurring in any other way. It must, of course, be remembered that a beam when tested for both shear and bending moment, should be subject to a uniformly distributed load,

*Consulting Engineer, Union Trust Building, Detroit, Mich.

not to a concentrated center load; for, a beam loaded according to this latter method would only develop one-half the shear which exists in a uniformly loaded beam for a given bending moment.

Taking, for example, a certain beam, as shown in Fig. 1, and considering the cross-section AA; the tension strain on each fiber below the neutral axis varies in proportion to its distance therefrom. The vertical shearing strain is, however, practically constant. The resultant strain on

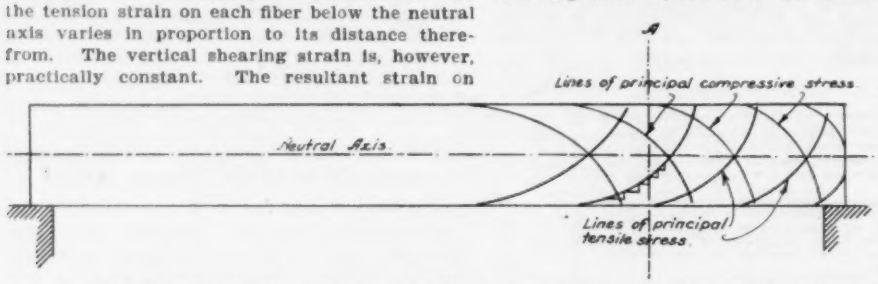


FIG. 1. DIAGRAM SHOWING LINES OF PRINCIPAL STRESS IN A UNIFORMLY LOADED BEAM SUPPORTED AT ENDS.

any particle should therefore be a combination of these two components, producing a line of principal tensile stress, which is one of variable curvature from the bottom of the beam to the top.

This theory of lines of principal tensile stress in a beam of granular composition, was, of course, advanced by Rankine many years ago, and to the writer's knowledge, Captain Sewell was the first to make public the very close relation between the theory and the actual tests in re-enforced concrete beams, when these were loaded to destruction. The writer begs to refer to the article which appeared in the issue of Engineering News of Jan. 29, and in which these lines of principal tensile stress are clearly outlined.

It is true that this article by Captain Sewell was severely criticised by other engineers in succeeding issues. This was done, however, without bringing forward substantial tests to prove differently. In fact, the attempts to prove the contrary seemed to the writer very weak indeed. In one case, a number of tests were cited, which, upon investigation, proved to have been centrally loaded beams. In another case beams of such proportions were tested as would be absolutely impracticable in the ordinary run of building construction.

If, then, lines of principal tensile stress exist throughout a beam, it is most natural that the concrete, being weak in tension, should open up at right angles to these lines, and this is what has occurred in all the tests which the writer has observed in well-proportioned concrete-steel beams, when tested to destruction under uniform load, and where the metal re-enforcement was horizontal only.

As has already been noted, European engineers endeavored to overcome the difficulty by placing stirrups throughout the beam, their distances apart varying, of course, in the inverse ratio of the shear. There seems no doubt whatever in the writer's mind that such stirrups accomplish a great deal of good, as they cross the lines of rupture at an angle, and tend to hold the material together. If, however, they are placed in a beam, they should be placed in a direction inclined to the horizontal, so as to lie more closely along the line of principal tensile stress, for if they lie in exactly this line, they also cut the actual line of rupture at right angles, and are therefore of maximum efficiency in holding together the concrete where its natural tendency is to open up. Furthermore, if such stirrups are

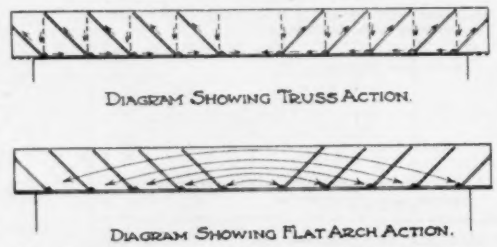


Fig. 3. Diagrams Showing Flat Arch and Truss Action of Concrete Beams Reinforced with Kahn Bar.

to carry stress, they should carry it into some member capable of receiving it, and the bottom chord member or the horizontal re-enforcement is there for that purpose.

In the first place, then, it seems to the writer that stirrups should be inclined to the vertical and preferably bent to a curvature to approximate the line of principal tensile stress, and, secondly, these stirrups should be rigidly connected to the main horizontal re-enforcing bar.

There is still another matter in connection with the steel re-enforcement for concrete beams which is also of great importance, in so far that it effects economy in the use of steel. In a uniformly loaded beam, the maximum bending moment occurs at the center, whereas the maximum shear occurs at the ends, and if the same quantity of steel re-enforcement is therefore placed along the bottom of the beam and extends the full length of it, it does seem to the writer that steel has been wasted so far as bending moment alone is concerned, and certainly the beam has been neglected so far as shear is concerned. A steel

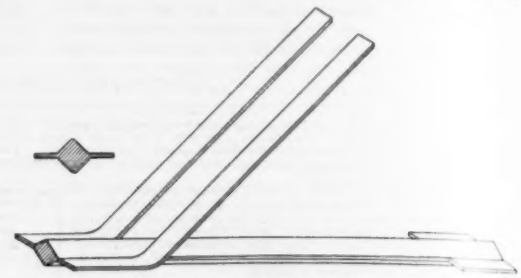


FIG. 2. SKETCH SHOWING CONSTRUCTION OF REINFORCING BAR FOR CONCRETE.

I-beam in the same manner is not an economical construction for uniform loading; its top and bottom flanges are only required at the center, and at this place only a very thin web; whereas at the ends the stress is almost altogether shear, and web alone is required with very little of top and bottom flanges.

In the system of concrete re-enforcement, which it is the purpose of this paper to describe, these two matters have been carefully considered. The fundamental principles of this type of re-enforcements are: (1) Concrete should be re-enforced in a vertical plane, as well as a horizontal one. (2) The re-enforcement should be inclined to the vertical, preferably with varying upward curvature, approximating the line of principal tensile stress. (3) The metal should be distributed in proportion to the strains existing at any place. (4) The shear members should be rigidly connected to the horizontal re-enforcement steel.

It has been endeavored to accomplish all of these results by taking a bar of the cross-section shown in Fig. 2, and shearing upwards into an inclined position the web on both sides of the main body bar, thereby forming substantially the tension members of the ordinary Pratt truss.

When such a structural member is embedded within a body of concrete, the latter unites firmly to the steel, and the combination of the two forms a trussed beam wherein the tensional members are made up of steel, and the missing compression members supplanted by the concrete. Concrete is excellent in compression; steel, in tension; and, thanks to the property of strong adhesion between the two, in their combination makes a most ideal beam.

Neglecting for a moment the matter of vertical re-enforcement, it is very evident that a bar sheared up as above described, can not possibly

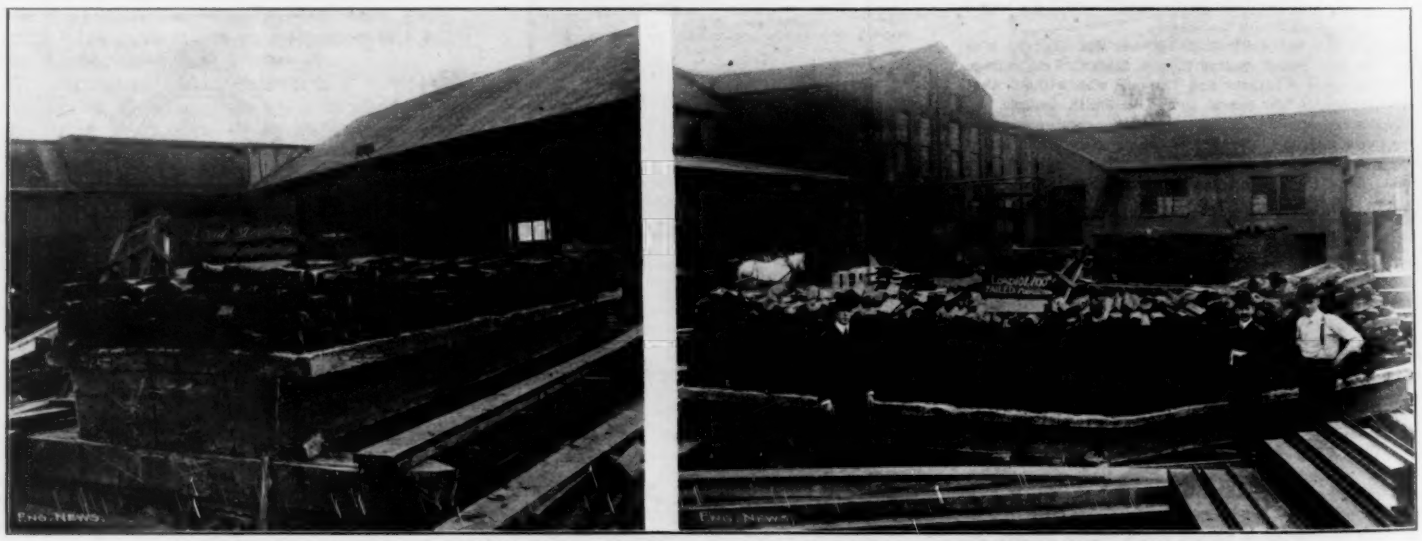


Fig. 4. View Showing Beam During Loading.

Fig. 5. View Showing Beam After Failure.

FIGS. 4 AND 5. UNIFORM LOAD TEST OF CONCRETE BEAM REINFORCED BY KAHN BAR.

slip through the concrete. The writer has actually taken blocks of concrete, molded to form the voussoirs of a flat arch, and then set them between the prongs. Such a beam, though set up without a particle of mortar between the joints, will carry a very large weight, and were it not for the large deflection which is caused by the poorly fitting surfaces between the prongs and the blocks, such a beam would carry weights to the same extent and on the same principle as when steel and concrete are actually united together.

This presents another way of looking at the reasons why this method of re-enforcement is so

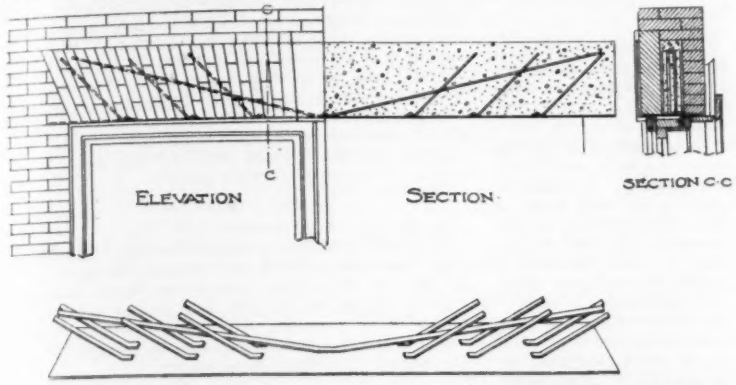


FIG. 6. CONCRETE LINTEL WITH KAHN REINFORCEMENT. TYPE A.

efficient. As soon as a load is applied on top of the beam, the concrete tends to arch itself, and a series of internal arches immediately set themselves up within the material, each arch finding its abutment in a set of prongs for which the bottom chord acts as a tie. The prongs receive the weight and carry it upwards, distributing on the other arches of larger span, the horizontal re-enforcement serving as a common tensional member (Fig. 3). It is plainly evident that with this construction the horizontal member might actually be placed outside of the concrete entirely, and the adhesion of the concrete to it entirely neglected, the strains coming into it being

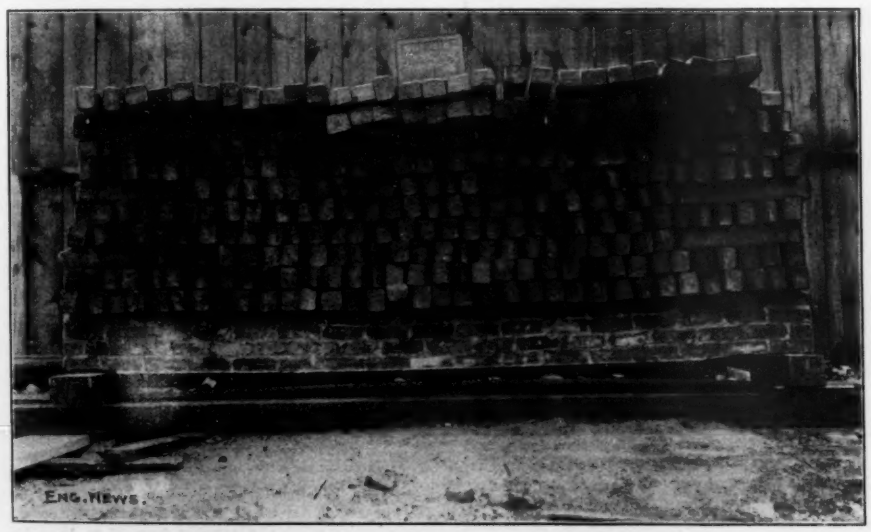


FIG. 8. VIEW SHOWING UNIFORM LOAD TEST OF REINFORCED CONCRETE LINTEL.

so largely the horizontal components of the inclined members.

Of course, for fireproofing purposes, and to prevent rusting, it is more advisable to imbed the steel within the concrete; and when this is done, advantage may be taken of both the adhesion of the concrete to the main bar and to the sheared-up members. In fact, with a given amount of concrete, a maximum amount of steel may be used, since the strains which it takes up are due to the direct adhesion of the concrete to it, plus the horizontal component of the inclined members. When such a beam fails, assuming that good material has been used for its construction, one of two things must happen—either the steel pull in two, or the concrete crush on top. The top portion of a concrete beam when used in floor construction is largely the floor itself, and it is generally impossible for this to fail in compression. It would seem, therefore, that a very large quantity of steel could be placed in the bottom of the beam to balance the compression. In fact, in all tests which the writer has made up to date, he has pulled the steel in two at the center of the beam.

Another point of great advantage of this construction is the fact that a beam need not necessarily be very wide to carry a given load; depth alone counts to advantage. The steel re-enforcement, depending entirely upon the stresses coming into it from the sheared up members, may be one large bar. This is practically impossible with constructions wherein the stresses coming into the steel are due to adhesion only of the concrete to it. Where such adhesion is depended upon, a large body of concrete must surround the steel to be able to transmit all of the strain which the bar is capable of taking. Whatever strain exists in the steel must be transmitted into the upper portion of the concrete through the medium of the concrete immediately surrounding it, and any one can readily perceive the great amount of horizontal shear, which must therefore exist throughout the body of the concrete, and the necessity of giving this great width. With this new method of concrete re-enforcement, however, the beam may be comparatively narrow; in fact, at the bottom it needs only to be sufficiently wide to encase the steel. It should taper upwards, however, widening towards the top, so that sufficient area may be given to the concrete to receive the compression. This, of course, makes a remarkable saving in the amount of this material used.

The strength of steel is, of course, a definitely determined matter. As for the concrete, it is not very expensive, and it would be advisable in all cases to give a small surplus of this material on the top of a beam, so that it will not fail by compression. With shear thus properly cared for, there is only one way in which the beam can possibly fail, and that is by the parting of the steel. Where this result can be assured with certainty, a concrete beam need no longer be subjected to a factor of safety of ten; the ordinarily adopted factor for steel, four, is sufficient, as such a beam is entirely dependent upon the steel and should be subject to close calculation in the same manner as a steel I-beam or a truss. When a concrete beam fails by shear, as has occurred almost without exception in tests up to date, then, indeed, the engineer stands more or less in mystery. In general it seems to the writer that whenever concrete is depended upon to carry other strains than direct compression, more or less risk is being assumed by the designing engineer, and a large factor of safety is strongly recommended.

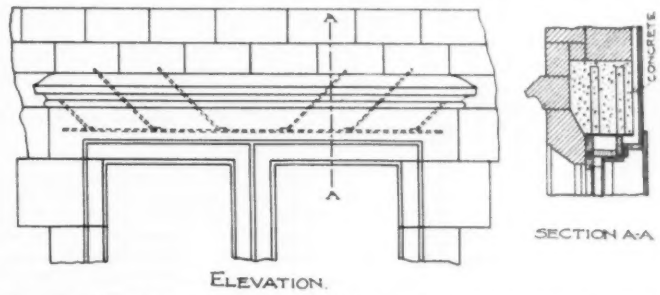


FIG. 7. CONCRETE LINTEL WITH KAHN REINFORCEMENT. TYPE C.

Some views (Figs. 4 and 5) are submitted herewith of tests made on two re-enforced concrete beams of 26-ft. span, c. to c. of supports, with a 4-in. thick concrete slab 5 ft. wide on top to receive the load. The concrete was made of Portland cement, sand and crushed stone, proportioned one, two and five. Loading was done with pig iron. Deflections were measured at the center. In one of the views, Fig. 4, an outline is shown of the actual cross-sections of the beams. The ends, it will be noted, are built up solid to give better bearing on the supporting timbers. The area of metal in the bottom of each beam was 2 sq. ins.

No deflection whatever could be observed in the beams until the load had reached 49,000 lbs. When 84,000 lbs. of pig iron had been loaded on the beams, making a total weight of 93,000 lbs. thereon, the floor slab weighing about 9,000 lbs., the actual deflection was 5/8-in. It was evident that the elastic limit of the steel had been well exceeded by this time. With 101,000 lbs. of pig iron, plus 9,000 lbs. for weight of slab, making a total of 110,000 lbs., the beam failed, breaking at the center, and pulling the steel in two at this point. Not a sign of a crack was to be seen throughout the beam at any other place than at the point of failure. This seems to the writer like a very remarkable test. The absolute lack of even a hair-line crack throughout any portion of the beam, except at the place of failure, is clear evidence that shear was properly provided for. As has already been explained, with this method of re-enforcement the adhesion of the concrete to the horizontal steel member is not essential; in fact, if the latter were placed entirely outside of the concrete, the beam would be very nearly as efficient as the strain which comes into this lower chord is so largely the summation of the horizontal components of the inclined members.

This principle is utilized in the Kahn trussed lintel, drawings of which are presented in Figs. 6 and 7. In the old system of lintels, an I-beam or built-up girder was figured on to carry the weight of the superimposed load, and a 12 × ¼-in or other similar plate was riveted to the bottom flanges of the beams to give bearing for the wall above, but the plate was counted upon as rendering little or no service in strengthening the lintel. In the new system this bearing plate not only supports the brickwork directly, but also acts as the bottom flange of a masonry beam, in which the masonry takes up the compression or thrust of a flat arch, while the steel plate takes up the tension. Diagonals, riveted to the base plate, form abutments for a series of arches of stress,

which set themselves up within the masonry, and for these the base plate serves as the bottom chord or tie. Each diagonal carries its weight upwards on the principle of the ordinary truss and spreads it on other arches of larger span, each of which has its corresponding abutment in a set of diagonals.

Another way of looking at the steel re-enforcement for such a masonry beam is to regard it as a half truss made up of tension members only, the masonry supplying the missing compression members, and the two being firmly united to each other through the cement, which forms a perfect bond between them.

One of the views, Fig. 8, shows such a lintel, consisting of a 12 × ¼-in. steel plate, to which 1 × ¼-in. diagonal members were riveted. The span was 12 ft.; height of lintel, 11 ins.; breadth, 12 ins. Steel billets weighing 110 to 170 lbs. were loaded on the beam until a total weight of 40,720 lbs. was reached, equal to 3,400 lbs. per lin. ft. of beam. The deflection was ¼-in. Loading was stopped at this point, as the beam was beginning to be very top-heavy, and it was feared might turn over and injure the workmen.

The above systems of concrete re-enforcement which have been described are controlled by patents granted and now pending, which are held by the Trussed Concrete Steel Co., Union Trust Building, Detroit, Mich.

THE NEW ALASKAN RAILROAD, known as the Council City & Solomon River R. R., will be finished about Nov. 1. Work was begun June 19, and 12 miles had been finished Sept. 9. The locomotives are the 23-ton locomotives formerly used on the Manhattan Elevated Ry. The entire cost of the line between Council City and Solomon is estimated at $900,000. Mr. E. A. Olds, of New York, is president of the company.

THE BUILDING for the Western Electric Co., of Chicago, the collapse of which was noted in this place in our last issue, was not designed by Messrs. E. C. & R. M. Shankland, as stated through misinformation, in our item last week concerning the fall of the building. We are informed that Messrs. Shankland were not the engineers of the building, nor did they have anything to do with its design or construction. They were called in as experts after the fall of the building, together with several other Chicago engineers.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision between work-trains on the Southern Pacific Ry., near Los Angeles, Cal., on Oct. 5. A construction train ran into a number of cars filled with laborers, standing on the track, and both trains were wrecked. Four of the men were killed outright.—An unusual occurrence in American railroading was a series of attempts, by unknown persons, to blow up trains on the Northern Pacific Ry. at various points in Montana. The first of these attempts was made several months ago, following a blackmailing letter; a bridge was partially wrecked by dynamite, but fortunately no train was in the neighborhood. Since then dynamite has been placed on the tracks in a number of other cases, and three or four freight trains have been wrecked and partly destroyed. The two latest attempts were made during the past week. No fatalities have yet resulted from the dynamiting.—A similar attempt, also only partly successful, was made on the Algoma Central & Hudson Bay R. R. on Oct. 7.

A DISCOVERY OF ASPHALT is reported to have been made in the bed of Great Salt Lake, Utah. The fall in the level of the north arm of the lake during the summer exposed large black patches of material which is said to be asphaltum of good quality. Many claims are being staked out.

A STREET RAILWAY ORDINANCE covering the question of extension of the present franchises of the Chicago City Ry., which question has been under dispute between the city and the company for a long time, has been prepared by a sub-committee of the council's local transportation committee. The ordinance does not specify the rate of compensation, but the city is demanding 20% of the gross earnings, while the company insists that 3% is a sufficient amount in view of the large expenditures to be made on improvements. The principal features of the ordinance, as drawn up, are as follows:

1. A grant for 20 years. At the expiration of that time the city may acquire the property by purchase, may let another company take the property, or may renew the grant.
2. Joint use of tracks with the Union Traction Co. wherever possible, and exchange of transfers with that company.
3. Substitution of the underground trolley for the present cable system.
4. Immediate renovation of roadbed, plant, and equipment, and maintenance of the lines in a first-class modern condition.
5. Removal of all dead tracks not used by the company and not required by public interest.
6. Use of the grooved rail in streets paved with granite, asphalt, brick, or wooden blocks.
7. Use of cars with center aisles and without footboards running the entire length of the sides.
8. Sprinkling streets for their entire width, and the sweeping of them if possible by car sweepers and sprinklers, and the removal of garbage and refuse by street cars if possible.
9. Use of poles by the city for stringing wires.
10. Making of detailed annual reports by the company.

REMARKABLE AUTUMN FLOODS were produced in eastern New York, northern New Jersey and northeastern Pennsylvania by an exceedingly intense coastal rain storm prevailing over that section during Thursday and Friday, Oct. 8 and 9. During the period preceding this storm there had been little or no rainfall anywhere in the eastern half of the United States except in the north central and lake states, where a lake-storm prevailed; for example, the heaviest precipitation during the 12 hours ending 8 a. m. of Oct. 8 was at Erie, Pa., where 1.44 ins. of rain fell. During Oct. 8 a coastal storm broke over the Atlantic coast region from Boston to Cape Hatteras; it brought a very heavy rainfall, which continued very steadily for about 27 hours. The maximum amount of precipitation occurred at New York; the figures of the local office of the U. S. Weather Bureau show a total rainfall of 10.04 ins. within 30 hours, nearly 9 ins. of which fell during the 24 hours ending 10 a. m., Friday, Oct. 9. The hourly figures for the New York station are as follows:

Rainfall at New York, as Given by the Local Office of the U. S. Weather Bureau.

Thursday, Oct. 8. Hour.	Rainfall.	Friday, Oct. 9 Hour.	Rainfall.
0 to 11 a. m.	0.10 ins.	0 to 1 a. m.	0.30 ins.
11 " 12 "	0.32 "	1 " 2 "	0.25 "
12 " 1 p. m.	0.10 "	2 " 3 "	0.75 "
1 " 2 "	0.05 "	3 " 4 "	0.34 "
2 " 3 "	0.06 "	4 " 5 "	0.46 "
3 " 4 "	0.34 "	5 " 6 "	0.41 "
4 " 5 "	0.01 "	6 " 7 "	0.29 "
5 " 6 "	0.10 "	7 " 8 "	0.51 "
6 " 7 "	0.02 "	8 " 9 "	1.38 "
7 " 8 "	0.93 "	9 " 10 "	1.04 "
8 " 9 "	0.32 "	10 " 11 "	0.03 "
9 " 10 "	0.24 "	11 " 12 "	0.23 "
10 " 11 "	0.27 "	12 " 1 p. m.	0.24 "
11 " 12 "	0.26 "	1 " 2 "	0.30 "
	3.12 ins.	2 " 3 "	0.33 "
		3 " 4 "	0.01 "
			6.92 ins.

The sustained high rate of rainfall shown by the above figures prevailed, in a somewhat lesser degree, over a very large area. The following 12-hour figures give some idea of the extent of the storm:

	12 hrs. ending Oct. 8. 8 p. m.	12 hrs. ending Oct. 9. 8 p. m.	12 hrs. ending Oct. 9. 8 p. m.
Albany, N. Y.	1.62 ins.	2.10 ins.	1.02 ins.
New York, N. Y.	2.03 "	4.40 "	3.61 "
Atlantic City, N. J.	1.56 "	2.56 "	4.02 "
Philadelphia, Pa.	1.02 "	0.40 "	1.66 "
Cape Hatteras, N. C.	....	0.80 "	0.80 "
Scranton, Pa.	....	.... "	2.40 "

The effects of this rainfall were most marked in the hilly portion of the affected area and along the smaller streams. As no rain had fallen just preceding the storm, and the groundwater level was therefore not abnormally high, the conditions were quite unfavorable to high flood levels. However, the 24-hour precipitation was so large that high and in some cases unprecedented flood-waves passed down all streams in the hill country of northern New Jersey and eastern Pennsylvania, particularly the Delaware, Susquehanna, Raritan and Passaic Rivers. The trunk lines running west from New York were all tied up or seriously hampered in service, either by washouts or by flooded tracks. At Trenton, N. J., for example, the Delaware River and Assinpink Creek overflowed the tracks of the Pennsylvania R. R. to a depth of some feet and blocked traffic over the line between New York and Philadelphia. The Delaware passed all previous recorded floodmarks. Occuring with an autumn rain, where no melting snow or frozen ground could aid the run-off, this is especially remarkable. A number of dam failures are reported, and, in several cases fatalities occurred. Scores of bridges were carried away all over the territory subject to the floods. The longest span carried out was, probably, a 650-ft. suspension bridge over the Delaware at Port Jervis, N. Y. The rain storm was accompanied by hurricane winds, especially along the coast, and vast damage was done to coast property.

TREATING MACADAM WITH TAR has been recently tried at Westfield, N. J. About a quarter of a mile of macadam, two months old, was swept clean and a thin coat of tar applied which was then covered with screenings and sweepings and rolled. An automobile driven at full speed over the finished surface failed to raise any dust. It is claimed by the Barret Co., who made this tar surfacing, that it costs not more than $450 per mile of macadam road for the tar surfacing. It is reported that other roads will be tar surfaced if at the end of a year this experimental section proves satisfactory. Tar asphalts have proved to be failures after a few years' time, and a year's test of this tar surfacing should not be accepted as conclusive.

ANOTHER SINGLE-PHASE TRACTION MOTOR is reported from Germany. The motor is the invention of an Austrian engineer and was built by the Union Company. It has been fitted to a car which is in experimental operation over a short suburban line at Berlin. The line-current is of 6,000 volts potential, and is taken by a bow-collector from an overhead trolley-wire. The full line-pressure is used on the motor. Under date of Aug. 27, Consul-General Mason, of Berlin, reported that the experimental runs had proven very satisfactory, and that "no sparking or other technical difficulty" had been encountered. Further details are not given.

TANDEM-COMPOUND FOUR-CYLINDER LOCOMOtives, now being built for the Atchison, Topeka & Santa Fe Ry. by the Baldwin Locomotive Works, have ten coupled driving wheels, and pony leading and trailing trucks, or 14 wheels in all. The cylinders are slightly inclined, and the main drivers are on the middle axle. The general dimensions are as follows:

Driving wheels	4 ft. 9 ins.
Truck wheels, leading	2 " 5½ "
Truck wheels, trailing	3 " 4 "
Wheelbase, driving	19 " 9 "
Wheelbase, total	35 " 11 "
Weight on drivers	234,580 lbs
Weight, total	287,240 "
Cylinders, h. p., (2)	19 × 32 ins.
Cylinders, l. p., (2)	30 × 32 "
Boiler, diameter	6 ft. 6¾ "
Working pressure	220 lbs.
Firebox	9 × 1⅛ ft.
Heating surface, tubes	4,586 sq. ft.
Heating surface, total	4,796 "
Grate area	58½ "
Tubes, 391; diameter	2¼ ins.
Tubes, length	20 ft.

A ROUTE-INDICATING SIGNAL, designed specially for use at terminals, has been invented by Mr. J. P. Annett, Chief Signal Superintendent of the London & Southwestern Ry., of England. Below the semaphore arm is a rectangular box with a panel for displaying the number of the route or track for which the signal is cleared. By this means a signal bridge and row of signals can be replaced with one signal and indicator, this one combination being sufficient for ten or twelve indications. The signal has been installed at Southampton and at Portsmouth Harbor, the latter station having eight tracks diverging from the west-bound main track. One signal now serves these eight tracks, and the enginemen are said to be very well satisfied, as they have now only the one signal to look for, which is particularly advantageous at this place, as fogs are frequent. The indicator shows illuminated figures at night, and is clearly visible at a distance of 900 ft. The indicator is interlocked with the switches, so that the signal cannot be cleared for any route or the number of that route displayed, unless the switches are properly set.

THE NEW MECHANICAL FILTER PLANT recently established by Cornell University has been giving very satisfactory analytical results, according to an announcement issued by President Schurman. Analyses by Professor Chamot on Oct. 1, 2, 3 and 5 showed a reduction to zero of color originally ranging from 13 to 40; a like reduction of turbidity from originals of 0.5 to 20; and the following reductions, on successive days, in bacteria: 500 to 5, or 99%; 780 to 3, or 99.6%; 1,200 to 5, or 99.58%; and 1,500 to 2, or 99.86%. Tests for bacterial gas producers and for indol production were generally decided positive for the unfiltered and always negative for the filtered water.

FOREST EXHIBITS AT THE ST. LOUIS EXPOSITION will be made by the governments of Germany and the United States. Two adjacent five-acre tracts, already partly covered by trees, have been assigned to each country. New trees will be set out, and the same general variety of trees will be shown in each exhibit. Beyond the similarities already mentioned, the two tracts will be largely in contrast, forestry methods and implements of each country being different in many respects, and the aim being to illustrate these so far as possible.